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Grabner et al.

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(45) **Date of Patent: Nov. 19, 2013**

(54) **SYSTEMS FOR DEPLOYING INTRAOCULAR SHUNTS**

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(65) **Prior Publication Data**

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Related U.S. Application Data

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(51) **Int. Cl.**

A61F 9/007	(2006.01)
A61F 2/14	(2006.01)
A61M 39/00	(2006.01)
A61M 25/01	(2006.01)
A61M 25/06	(2006.01)

(52) **U.S. Cl.**
USPC **604/8**; 604/93.01; 604/181; 604/264; 606/108; 623/1.11

(58) **Field of Classification Search**
USPC 604/8, 9, 10, 264, 43, 506, 60, 63, 73, 604/93.01, 117, 158, 59, 162, 164.01, 604/164.08, 164.09, 165.01; 606/167, 170, 606/172, 181, 184, 185, 190; 623/4.1, 5.11, 623/23.64
See application file for complete search history.

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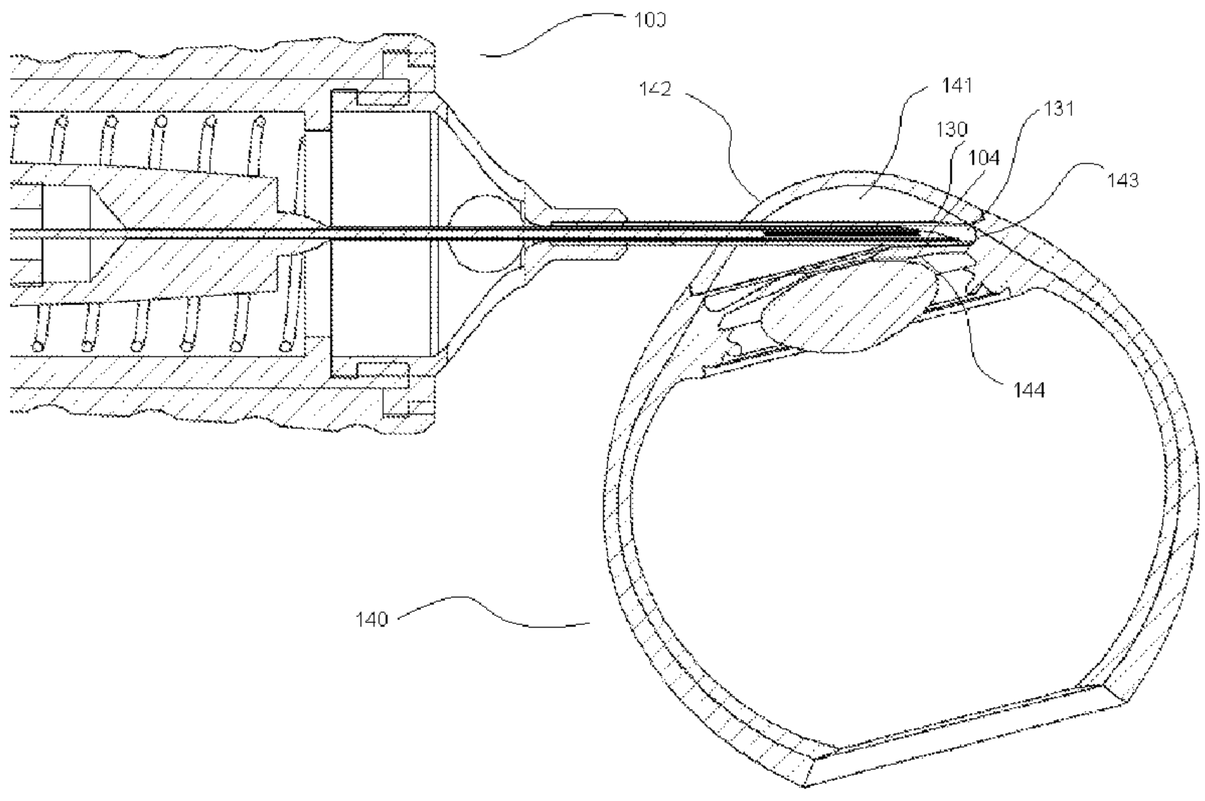
(74) *Attorney, Agent, or Firm* — James W. Hill; M. Todd Hales; McDermott Will & Emery LLP

(57) **ABSTRACT**

The present invention generally relates to systems for deploying intraocular shunts without the use of an optical apparatus that contacts an eye, such as a goniolens. In certain embodiments, systems of the invention include a locking mechanism, and a device configured to hold and deploy an intraocular shunt, in which a distal portion of the device is movable within a proximal portion of the device and the distal portion of the device is configured to mate with the locking mechanism to prevent movement of the distal portion when the locking mechanism is engaged.

28 Claims, 29 Drawing Sheets



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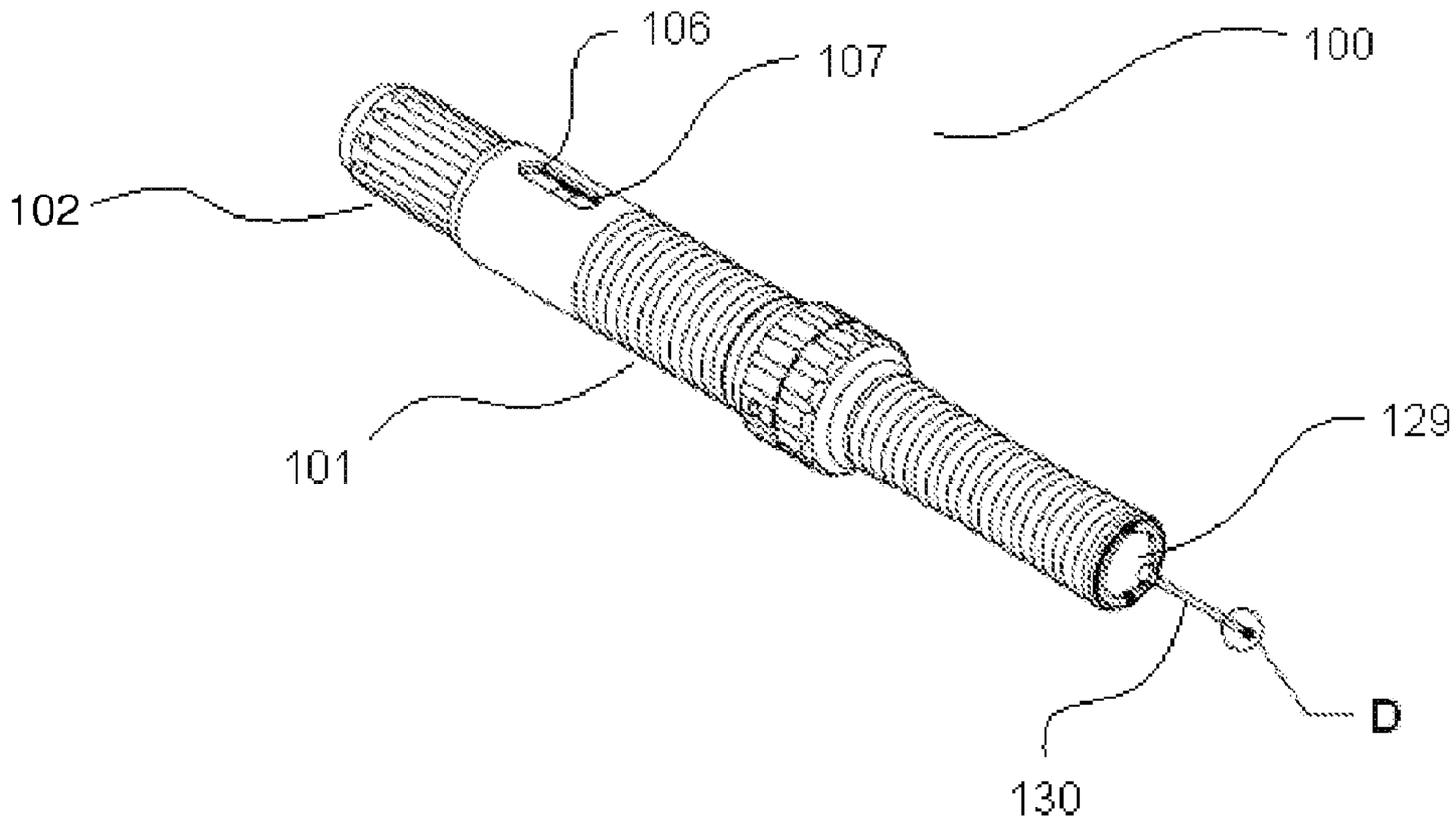

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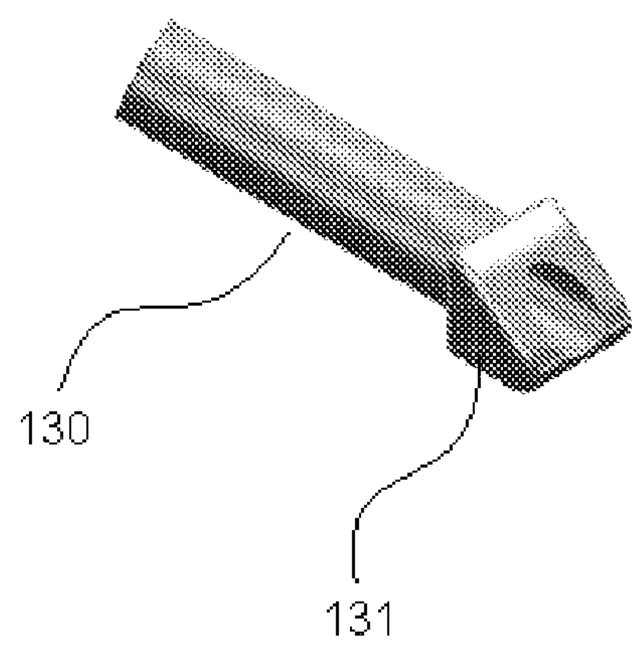

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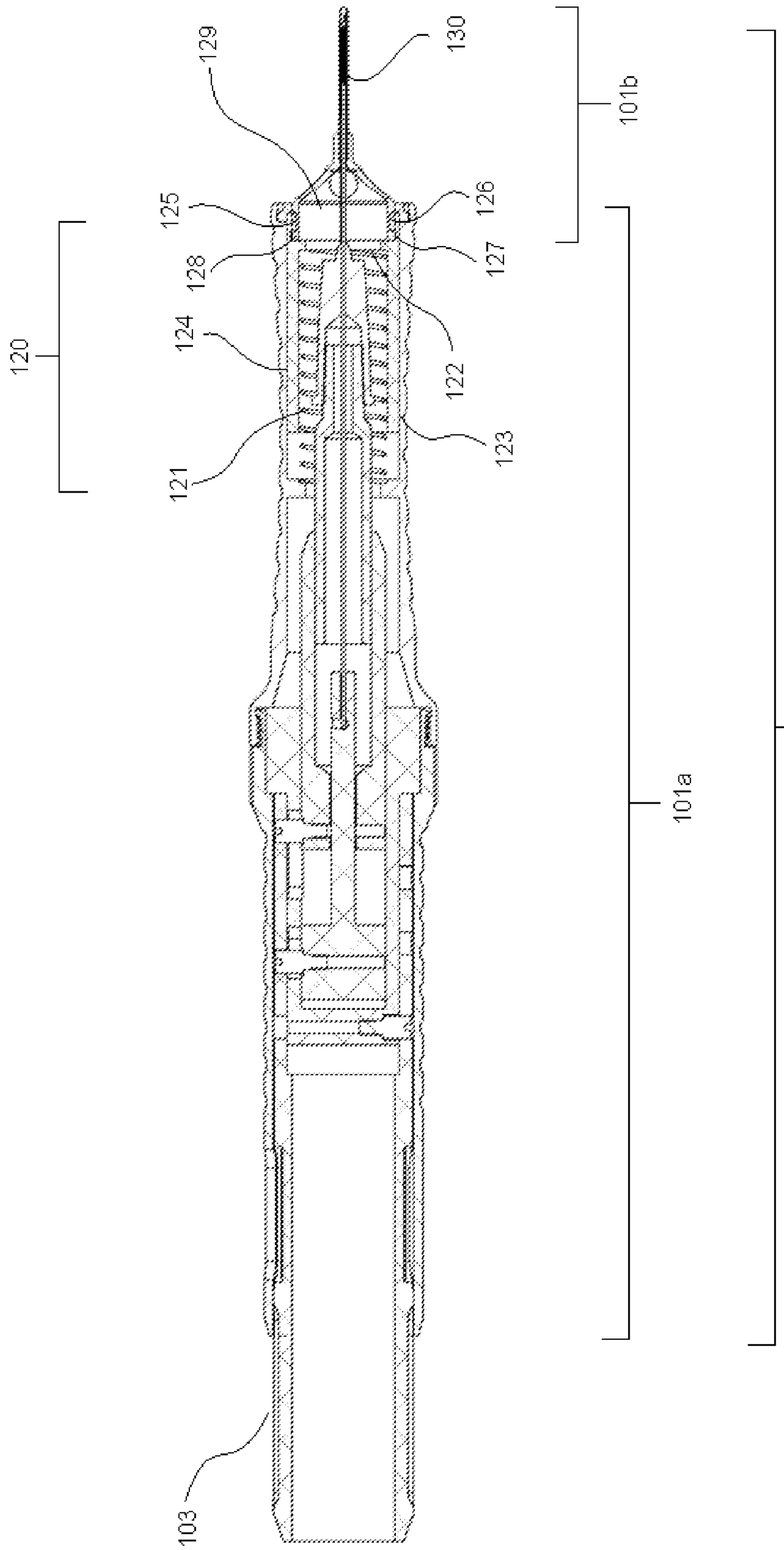

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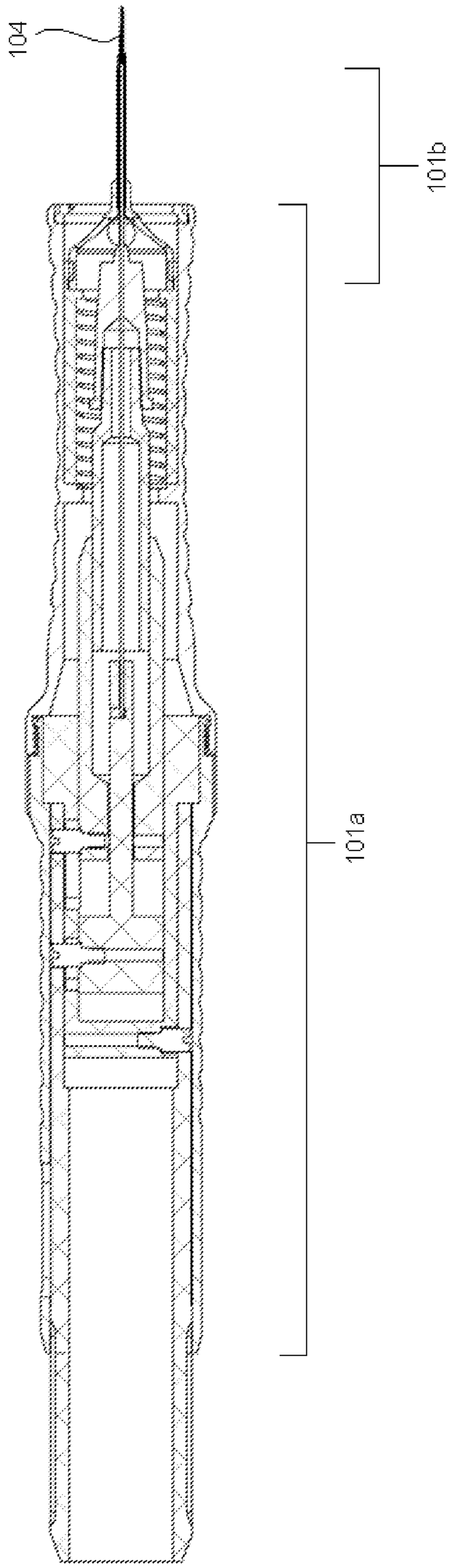

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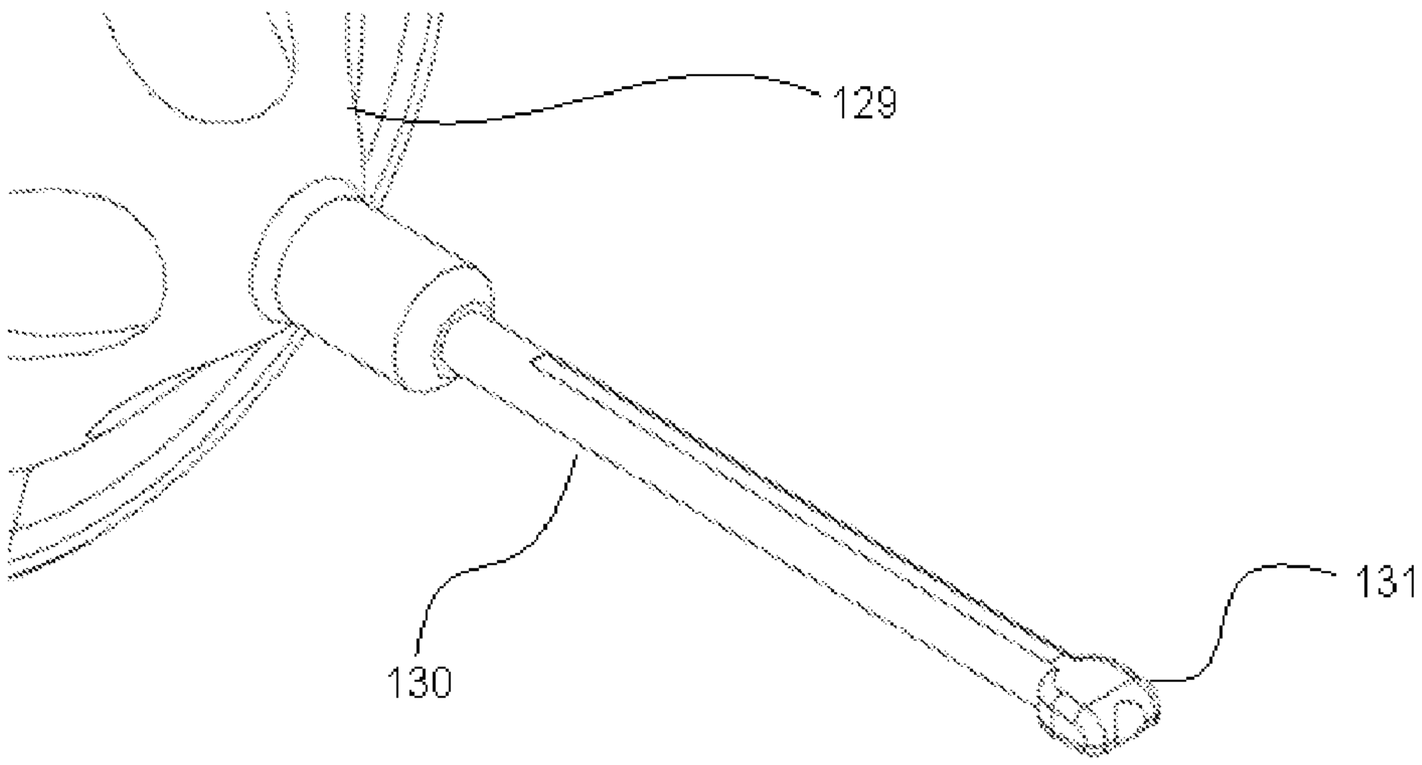

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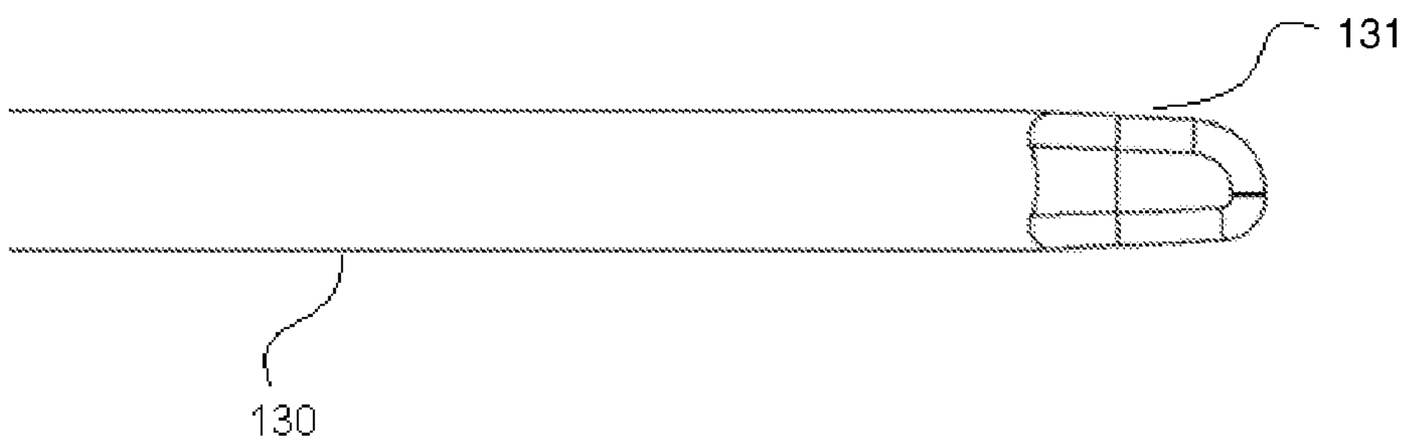

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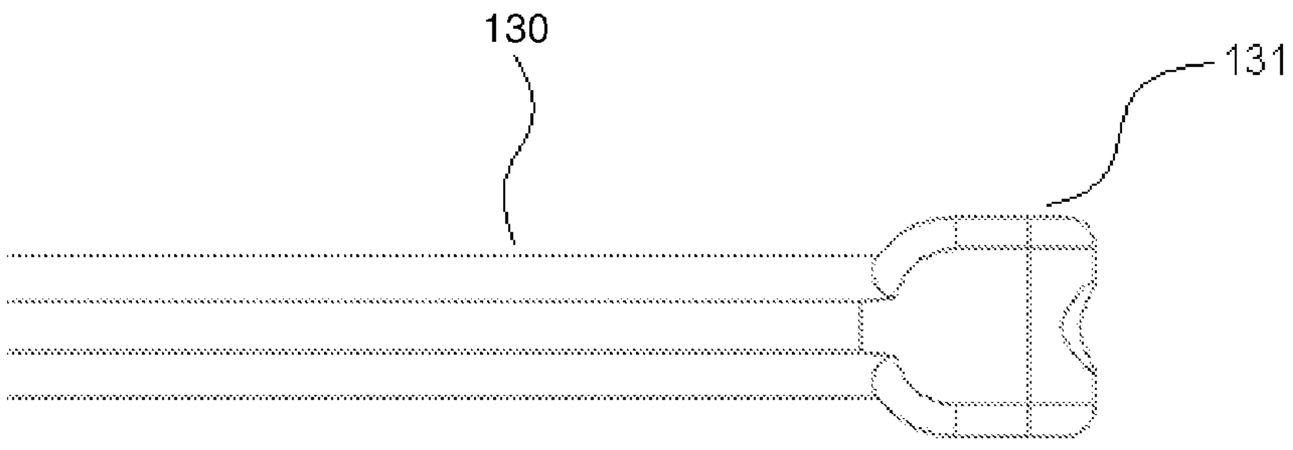

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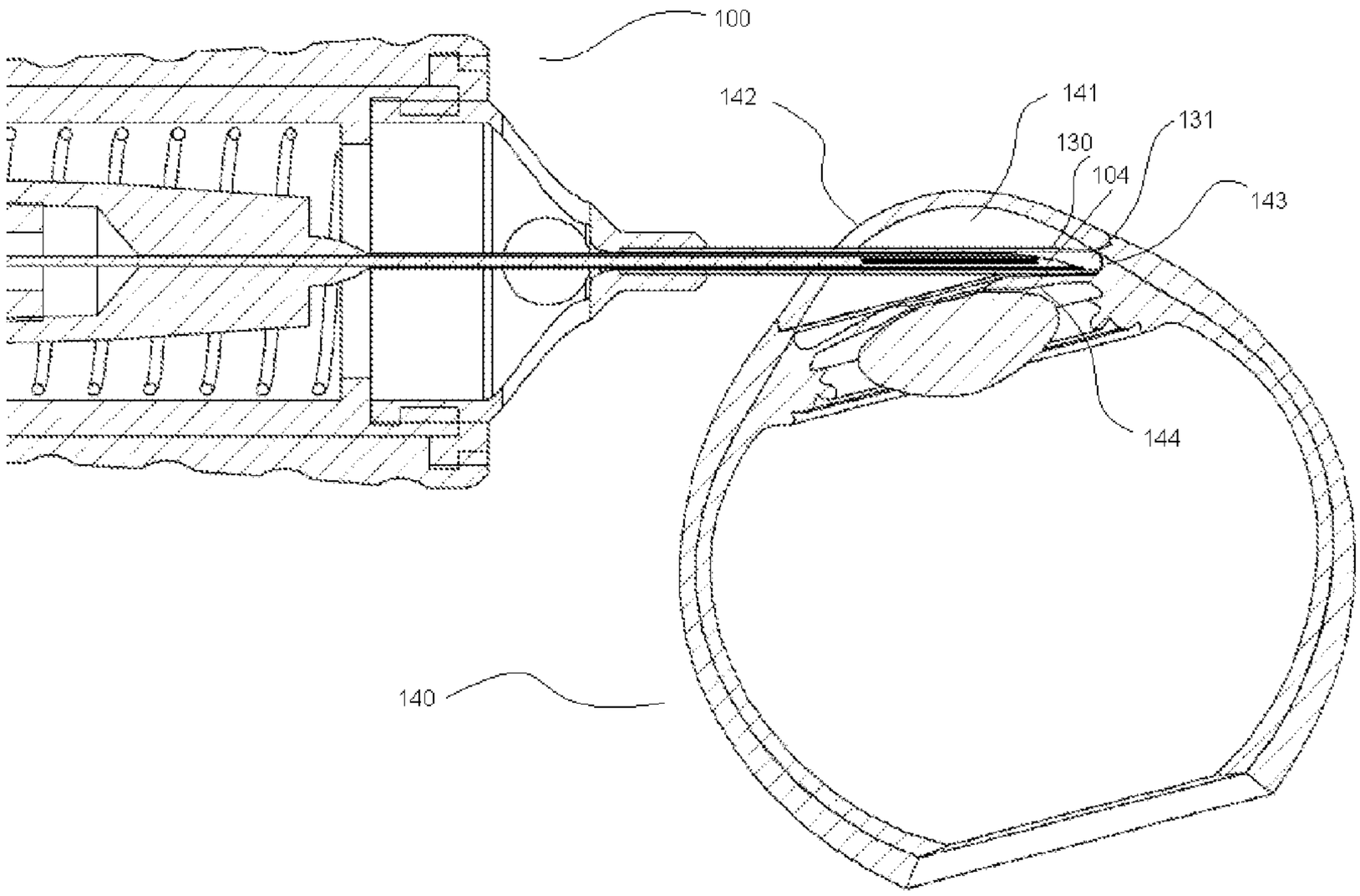
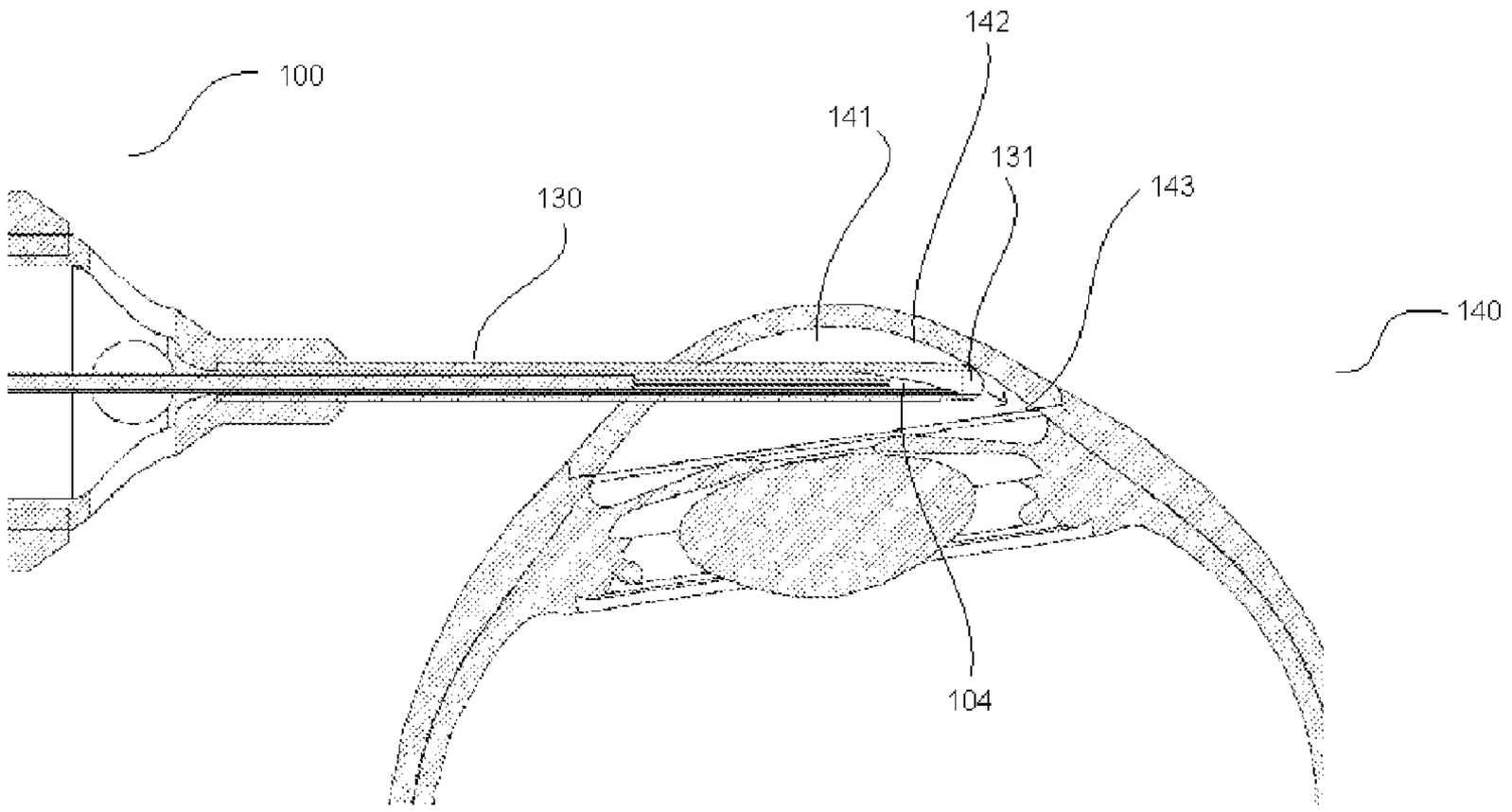


Figure 3A



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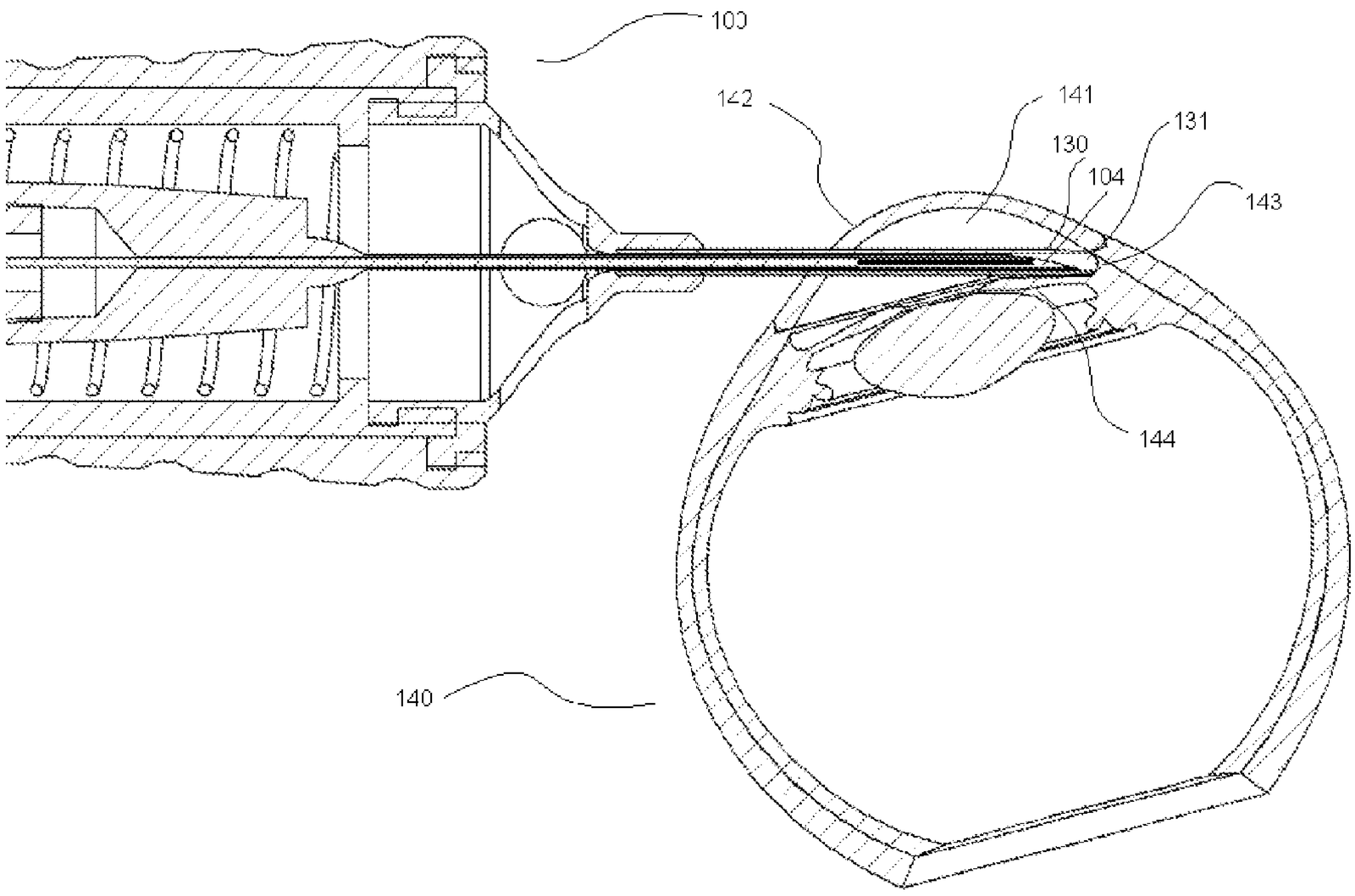

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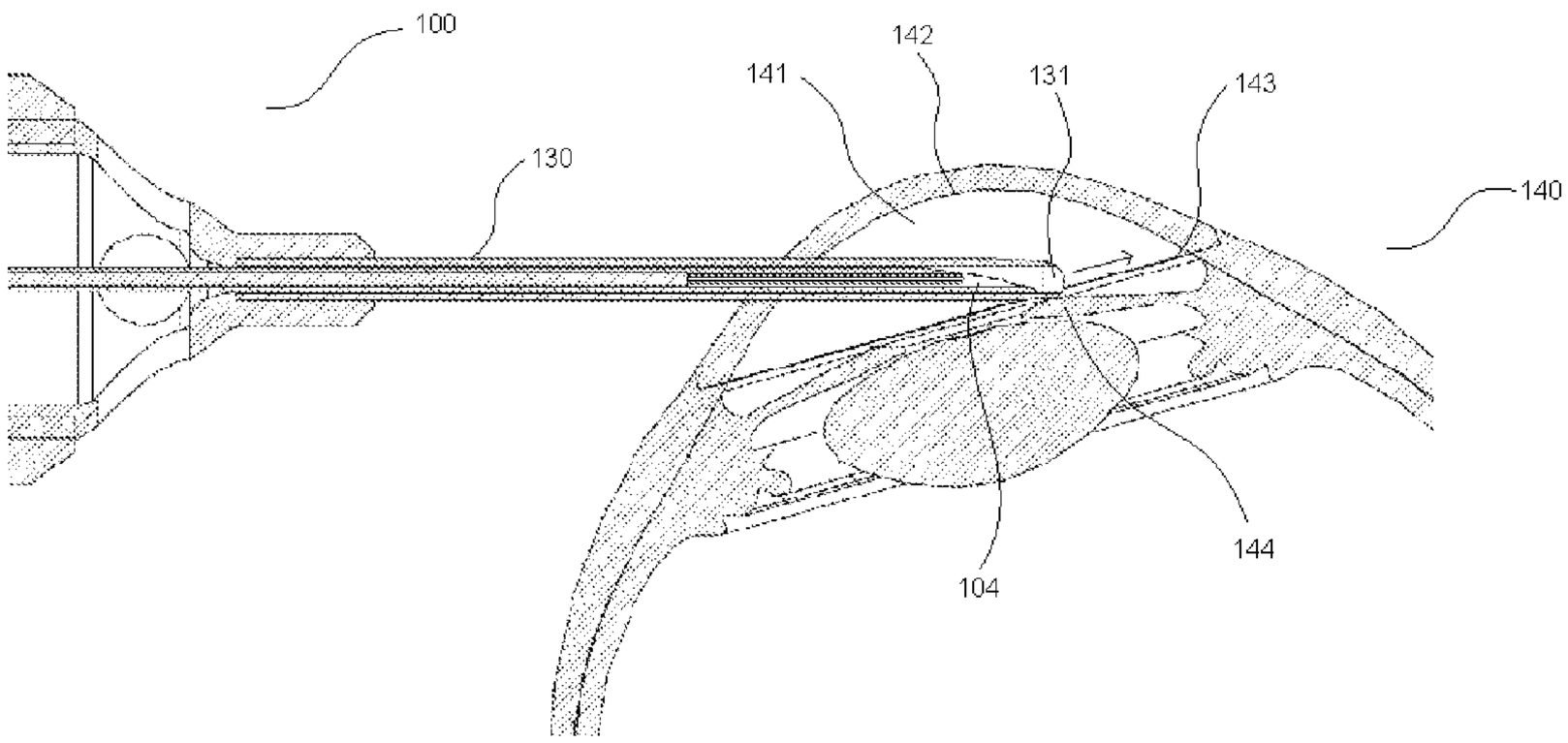

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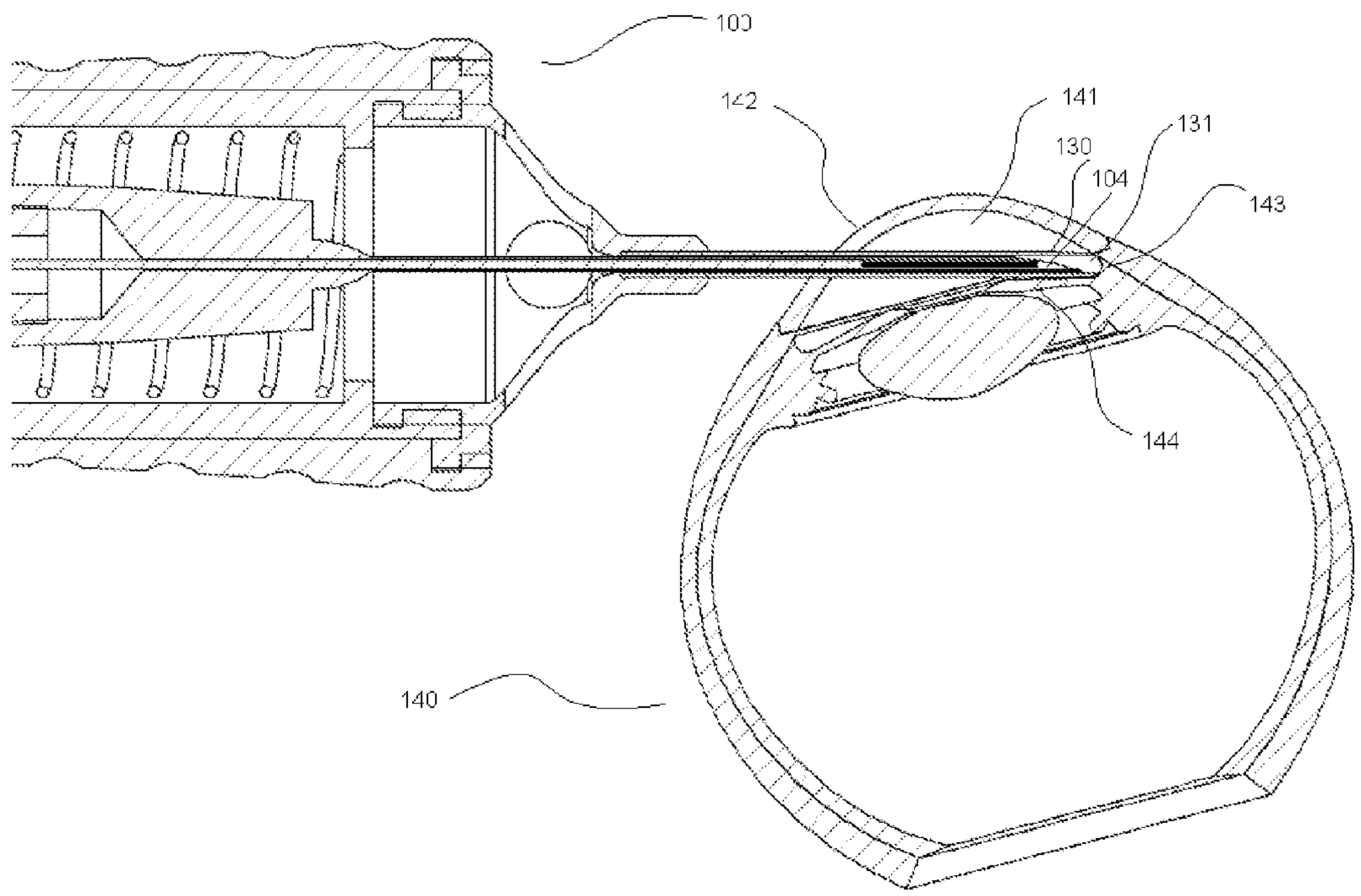
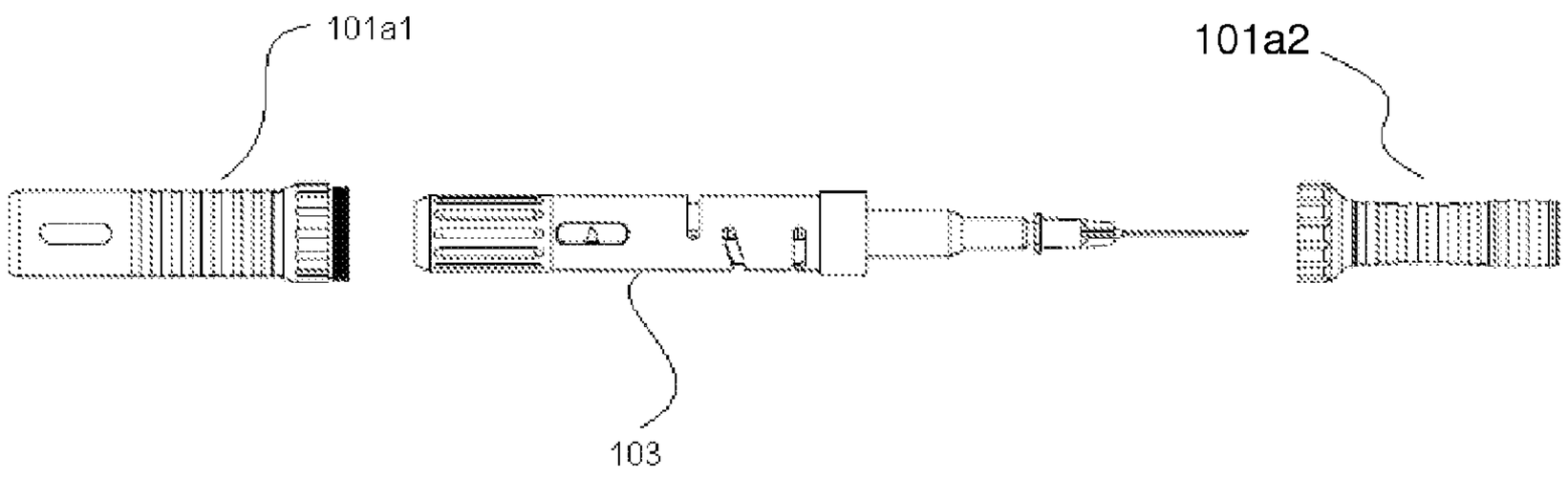


Figure 3E



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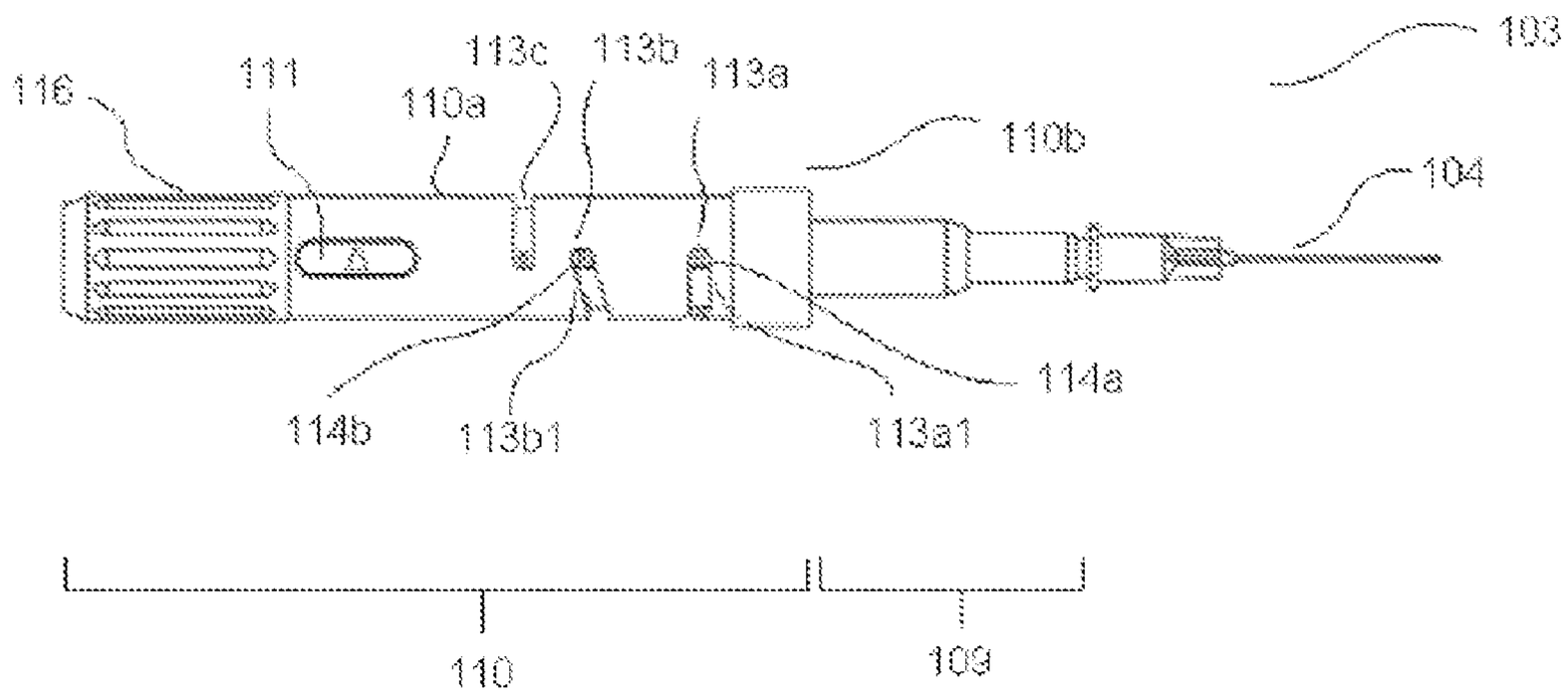

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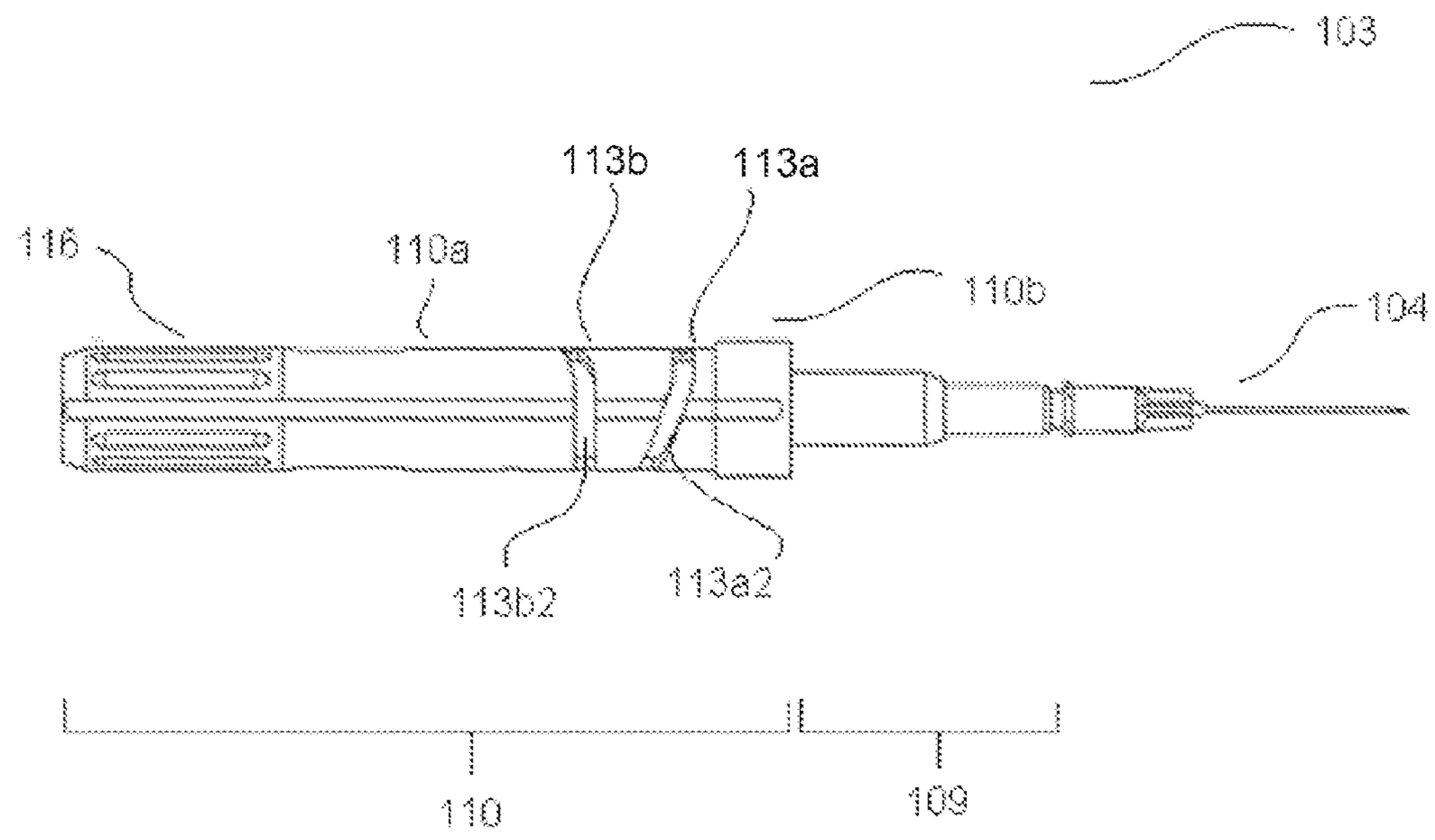

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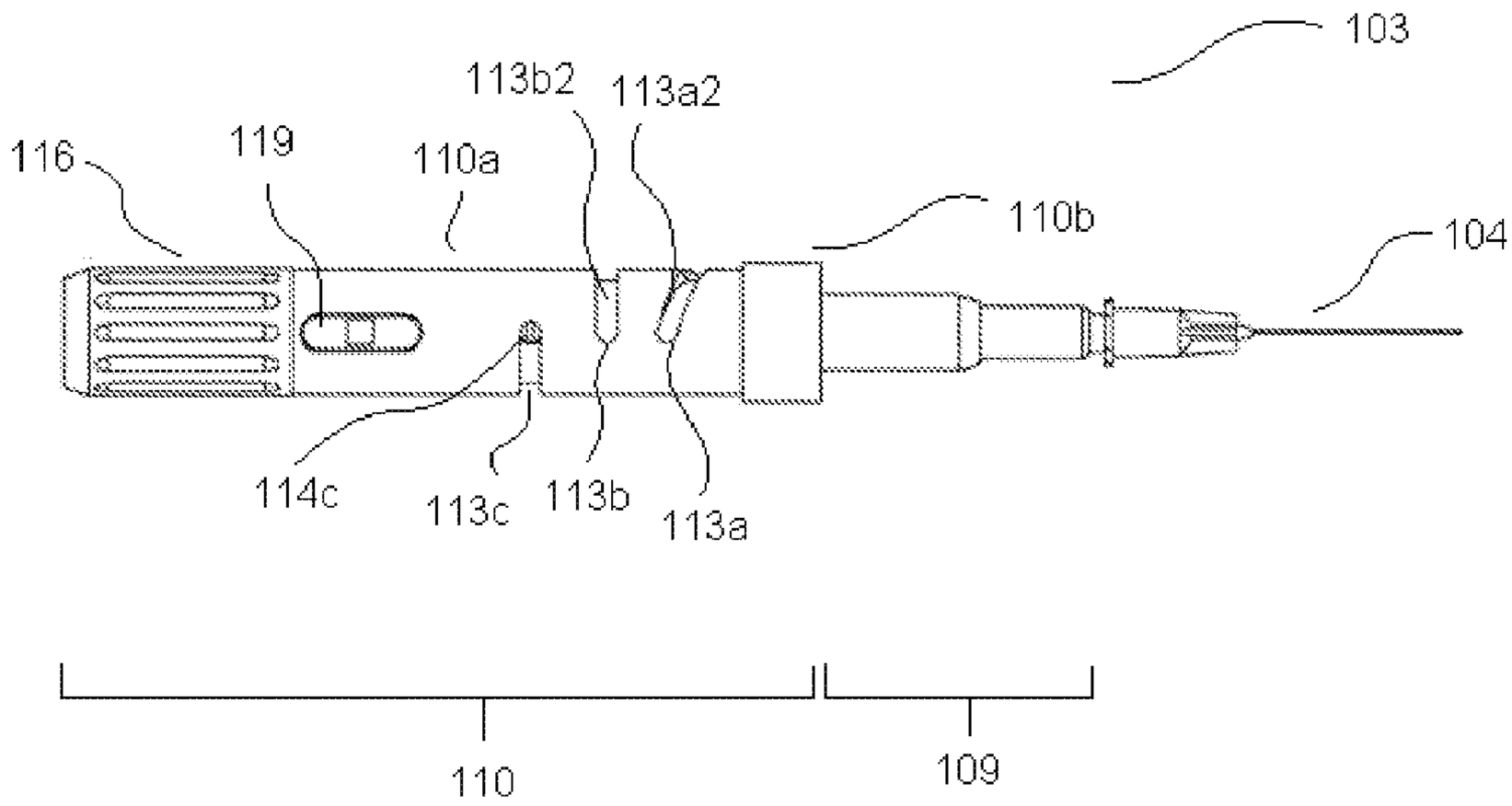

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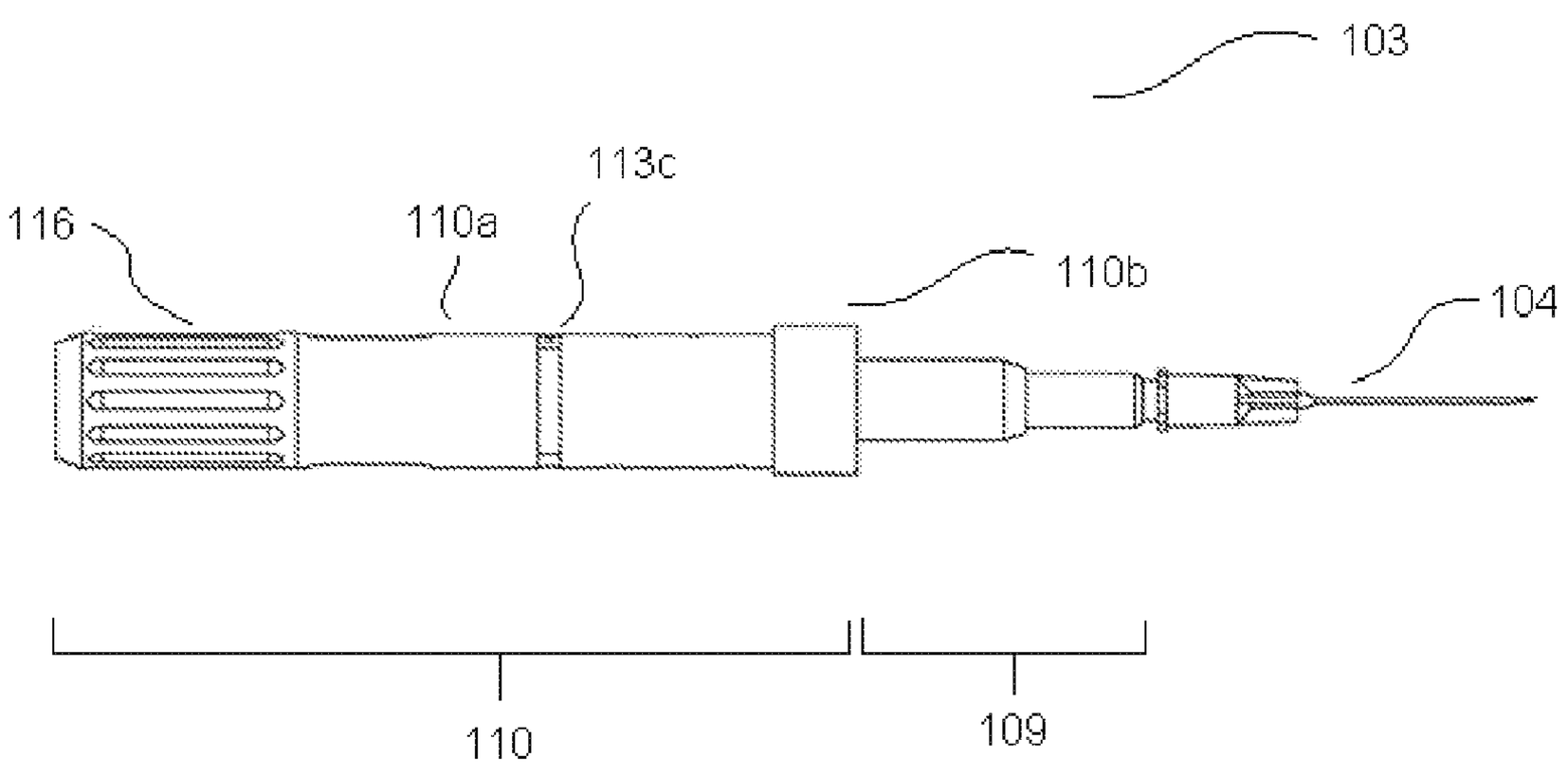

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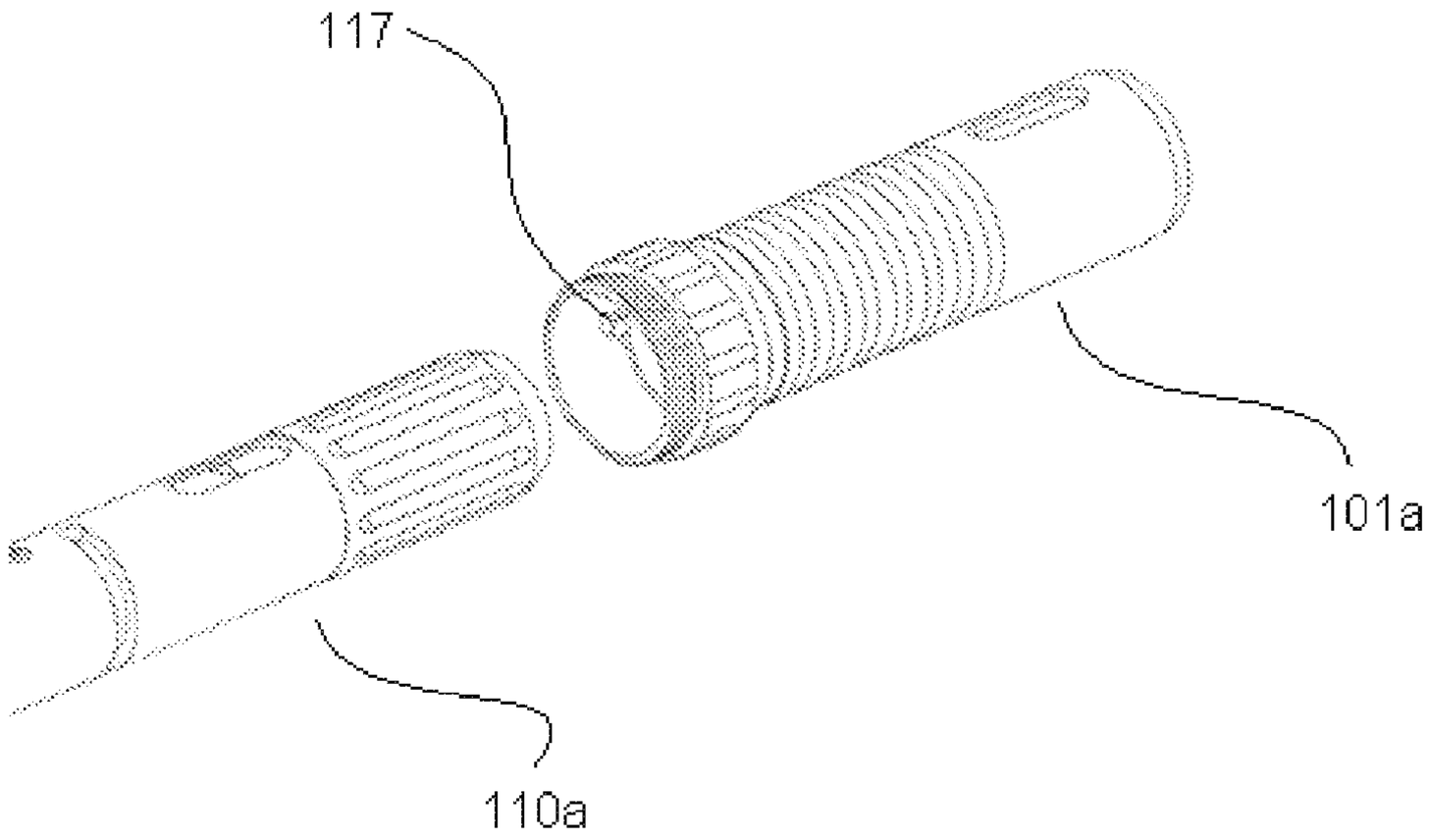
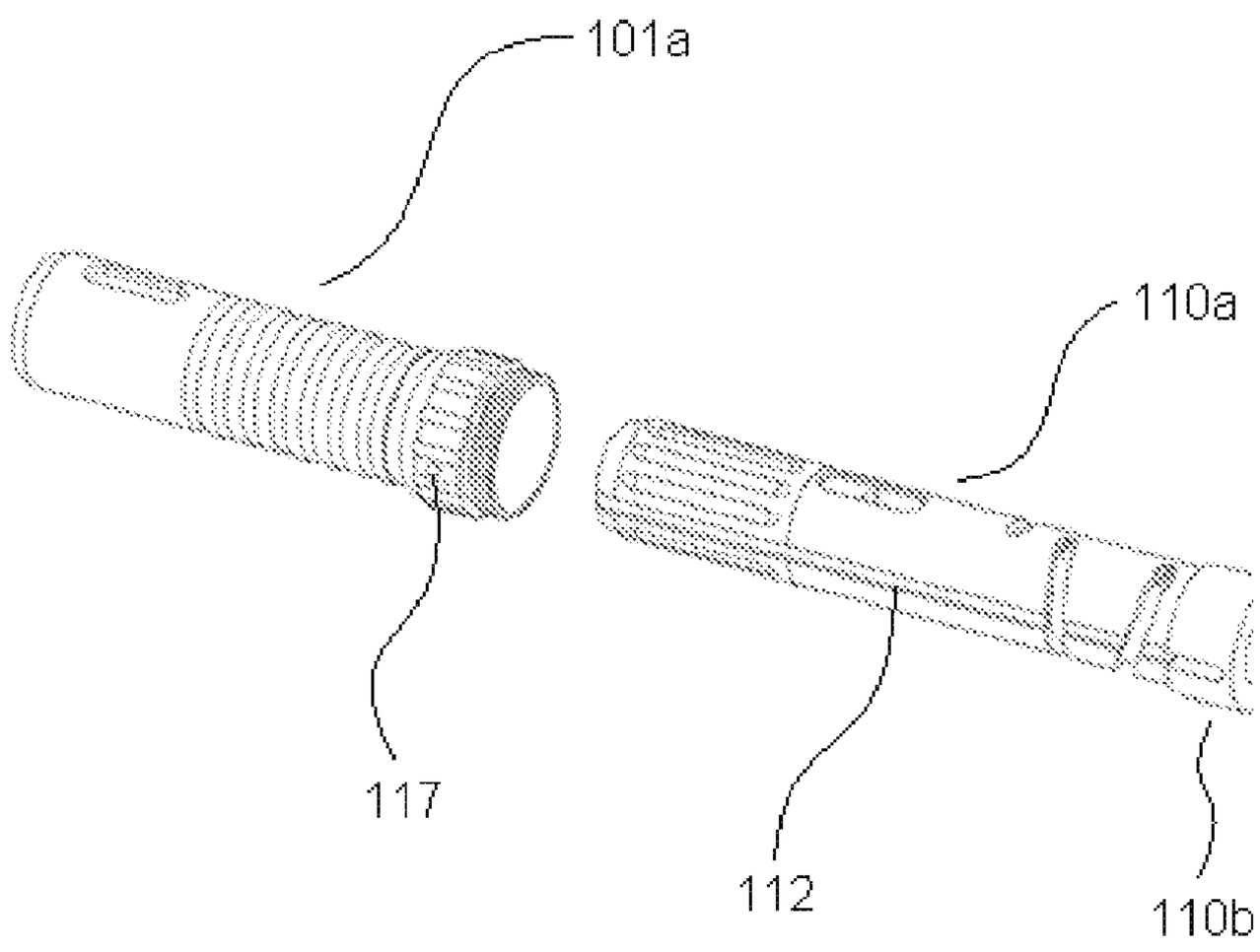


Figure 6A



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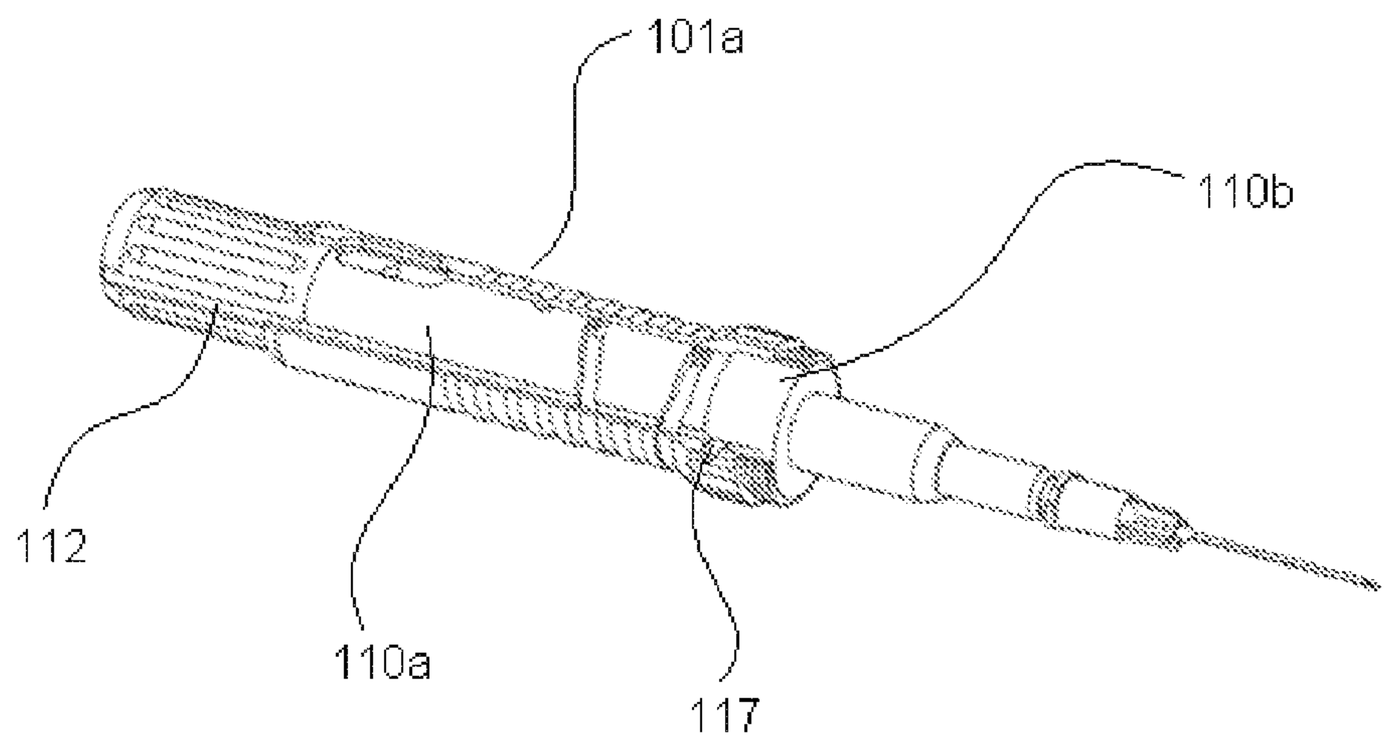

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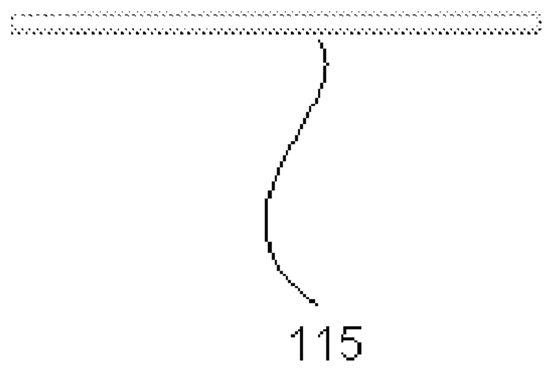

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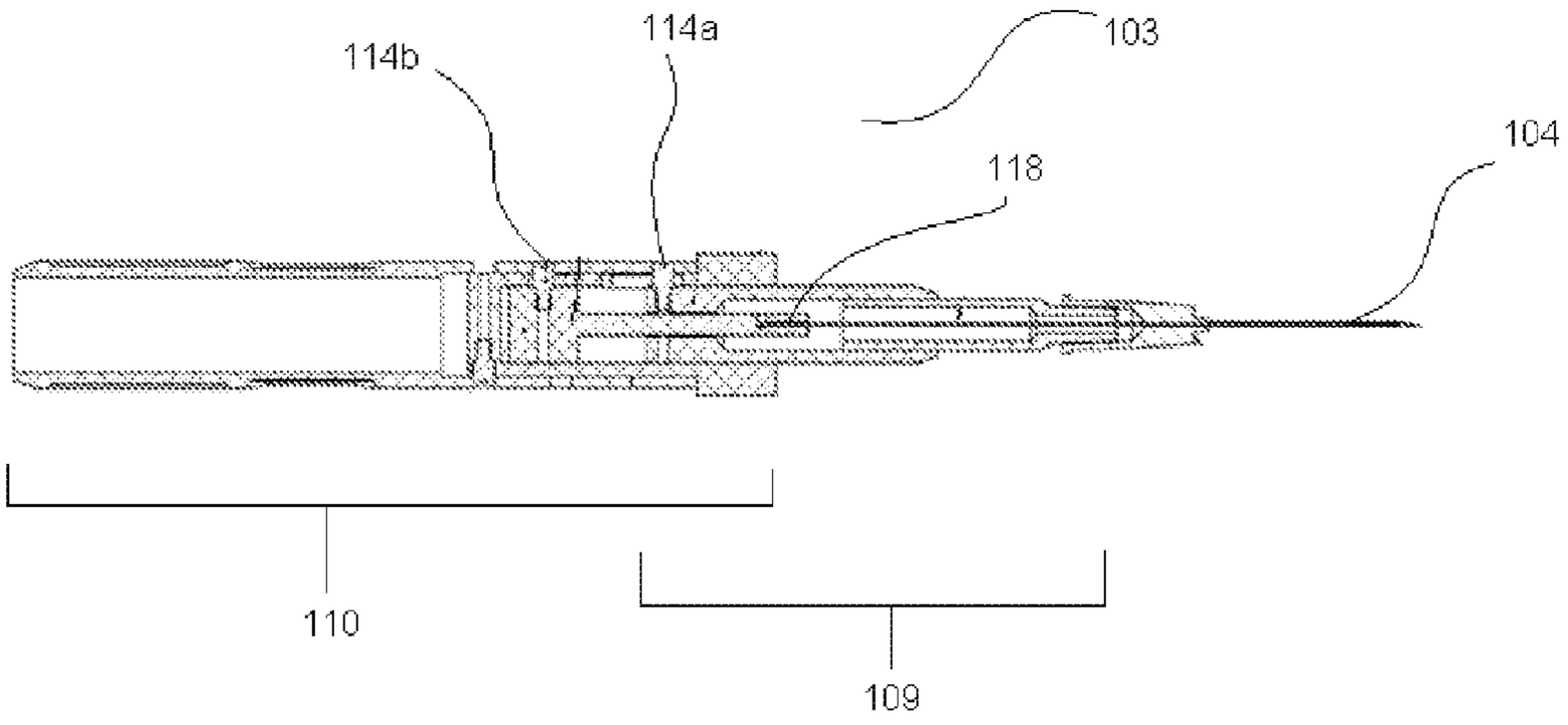

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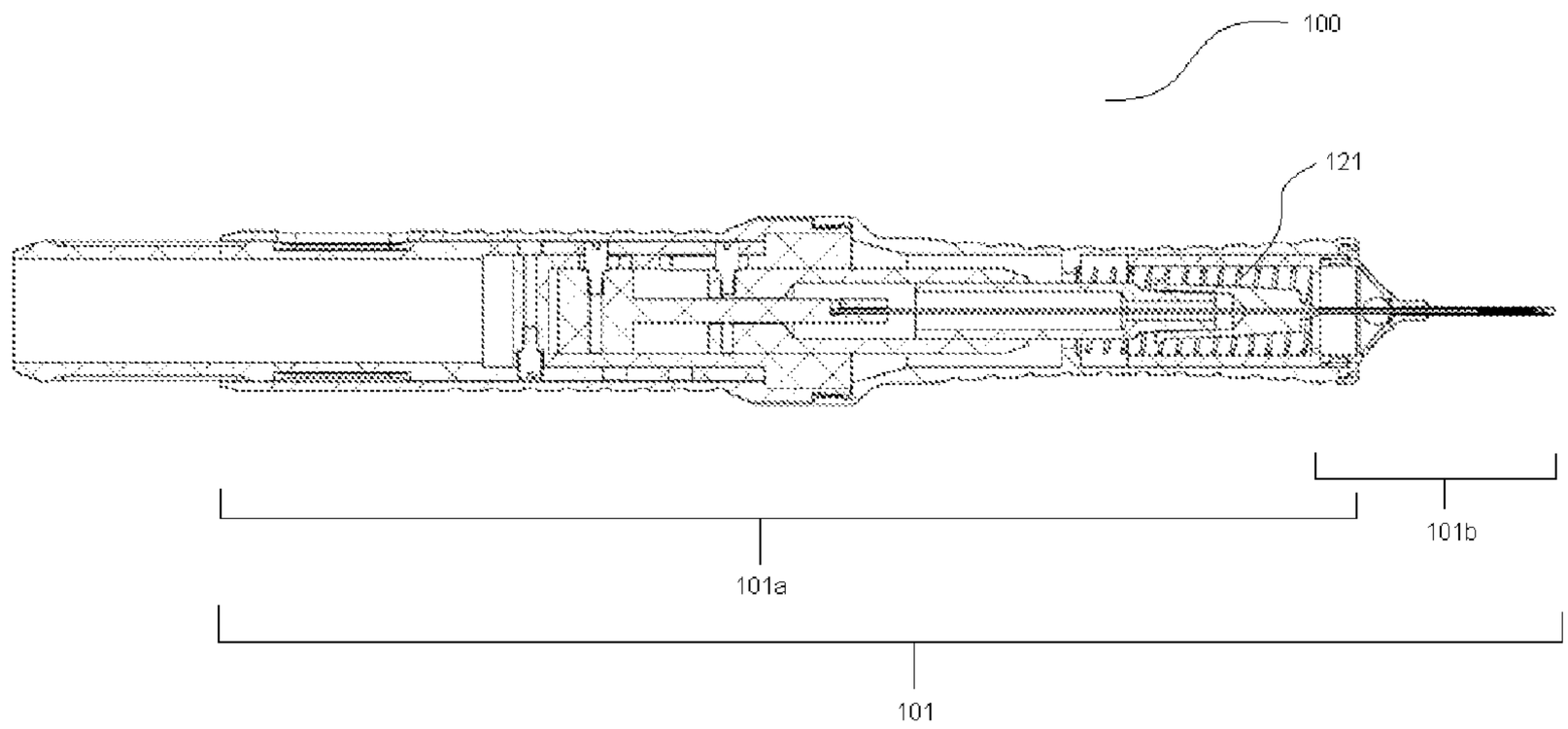


Figure 9A

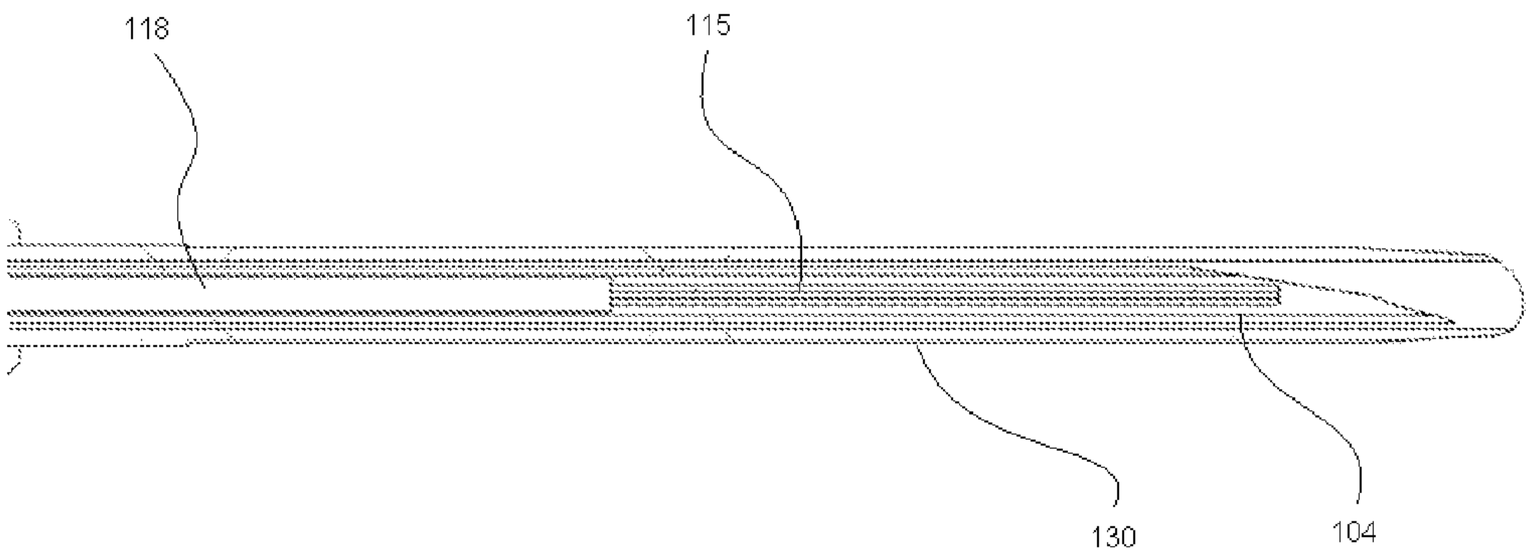
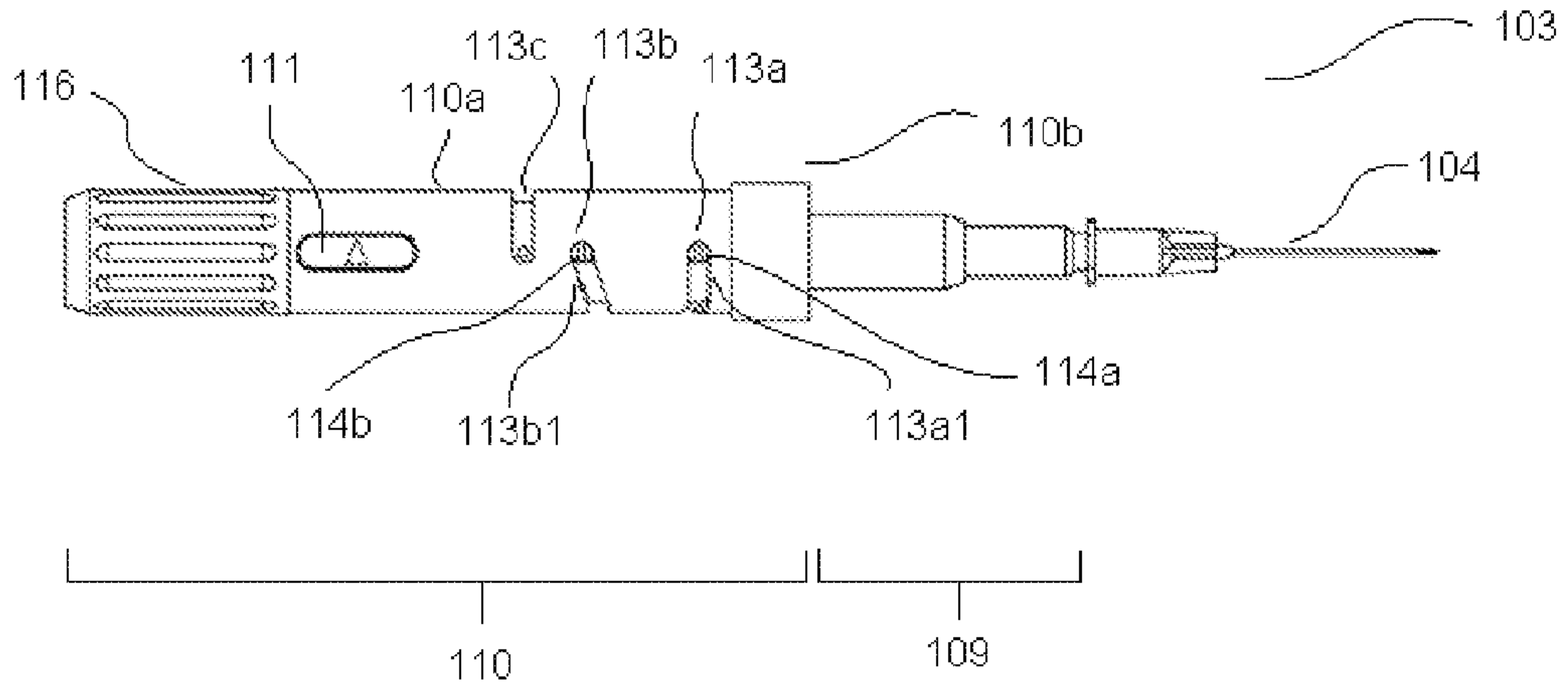


Figure 9B



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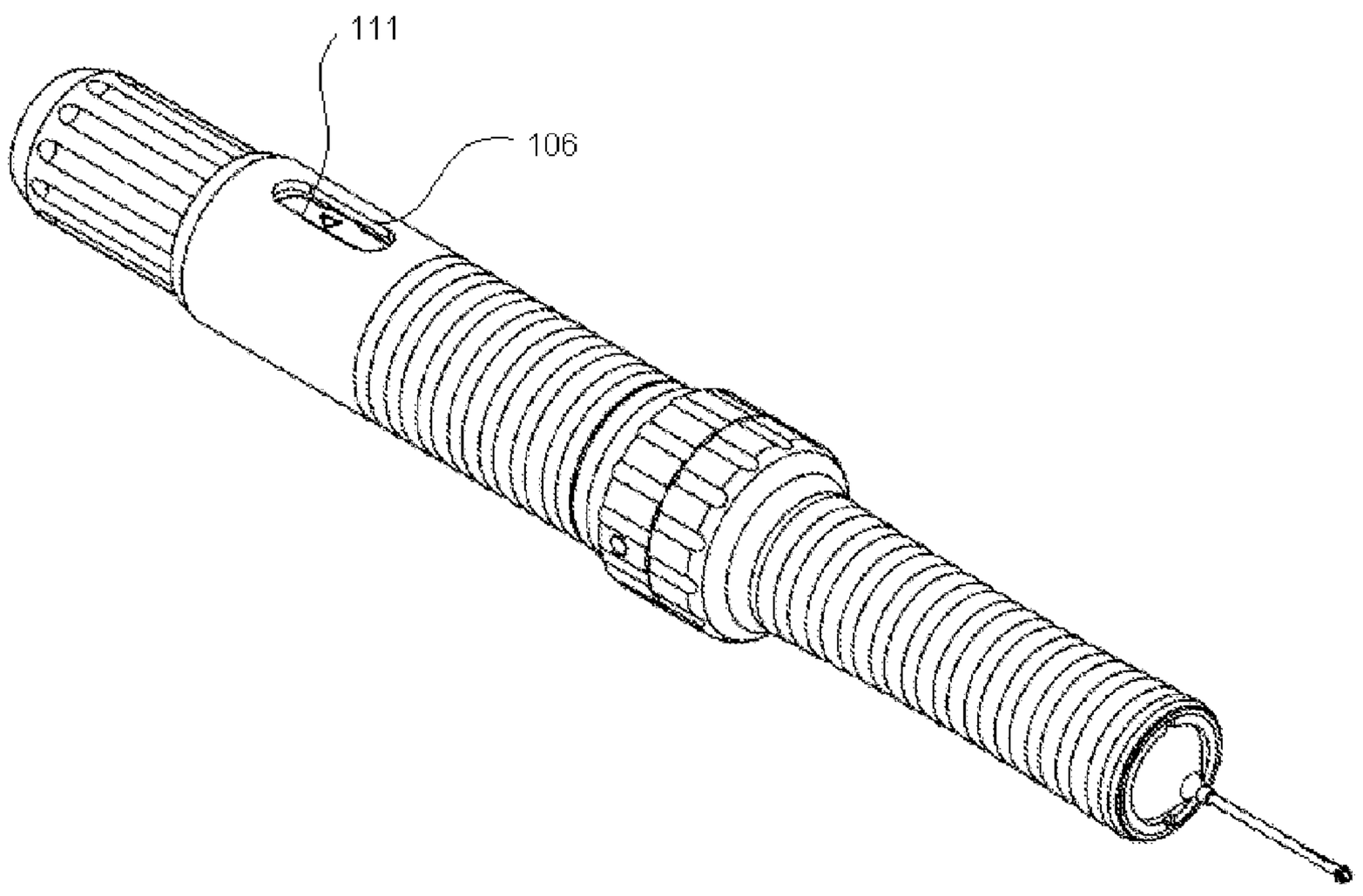

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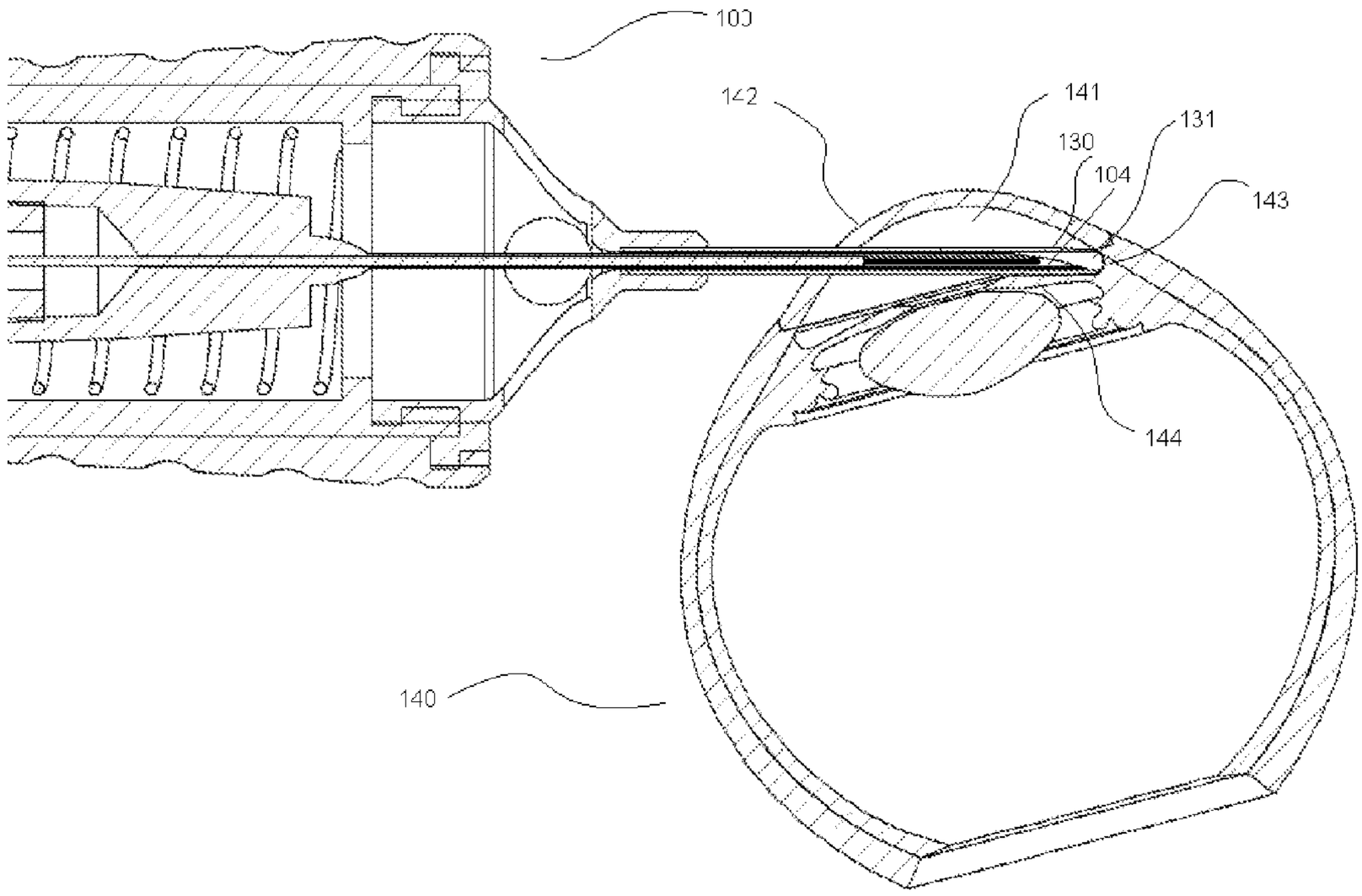

Figure 10

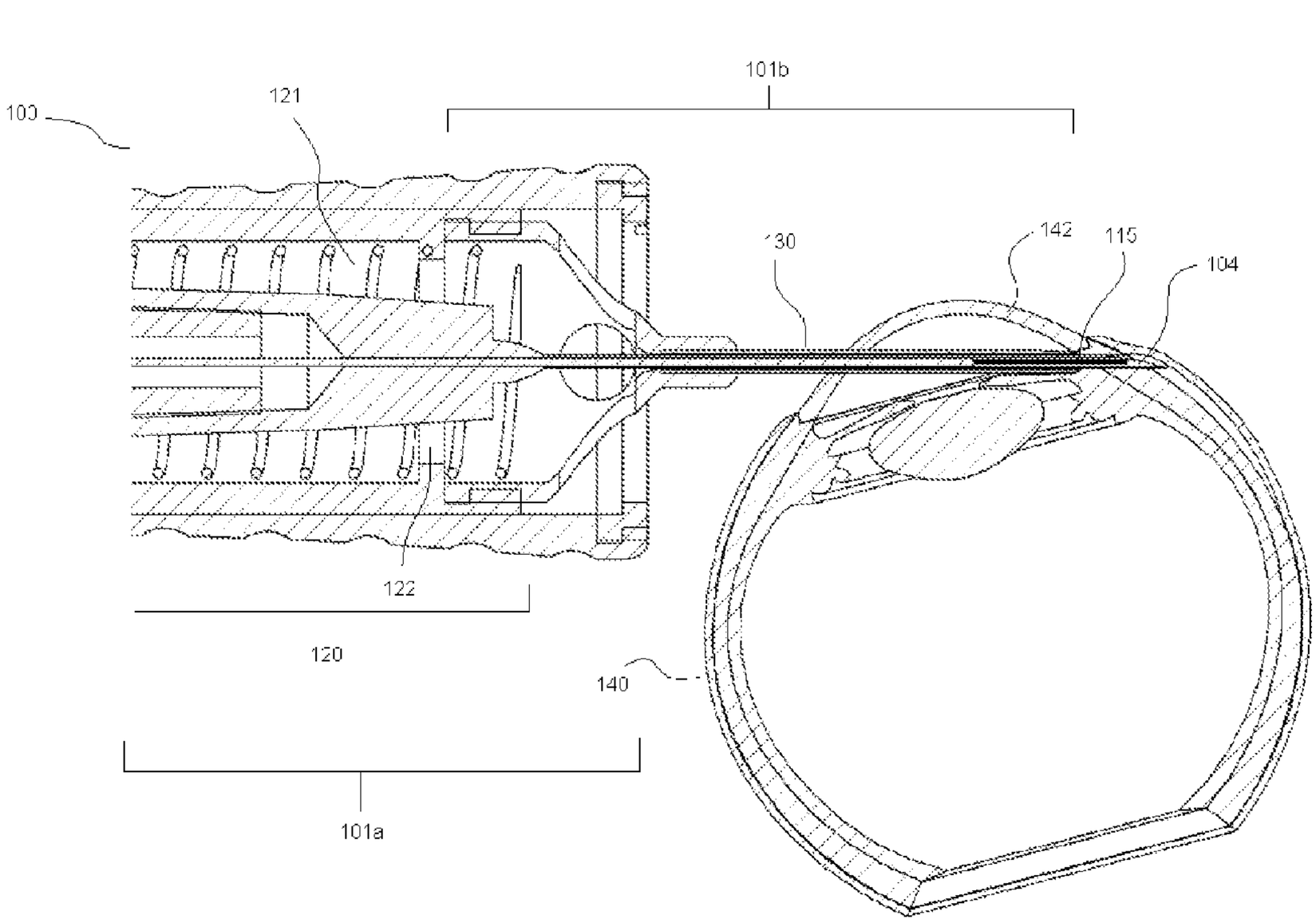

Figure 11

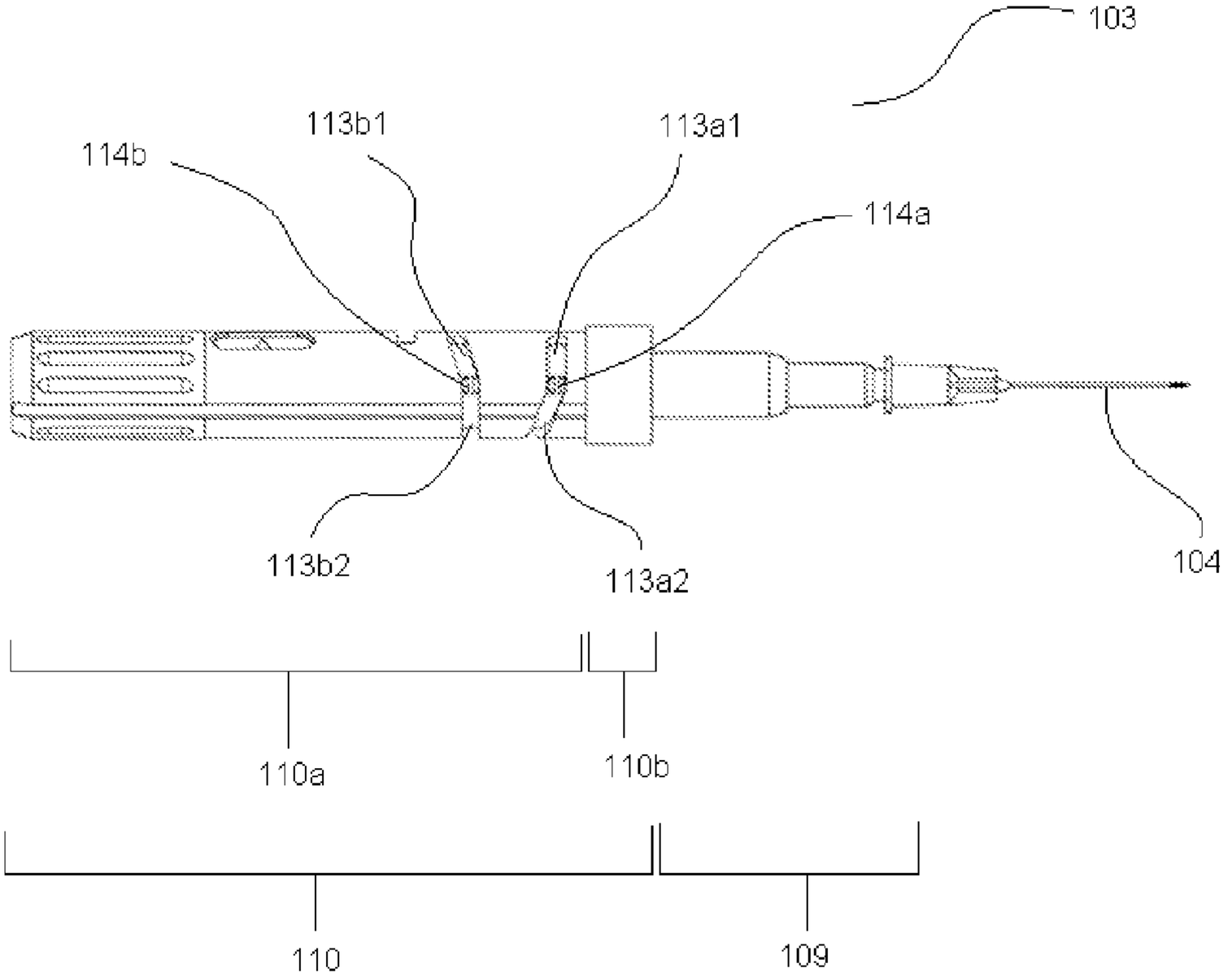

Figure 12A

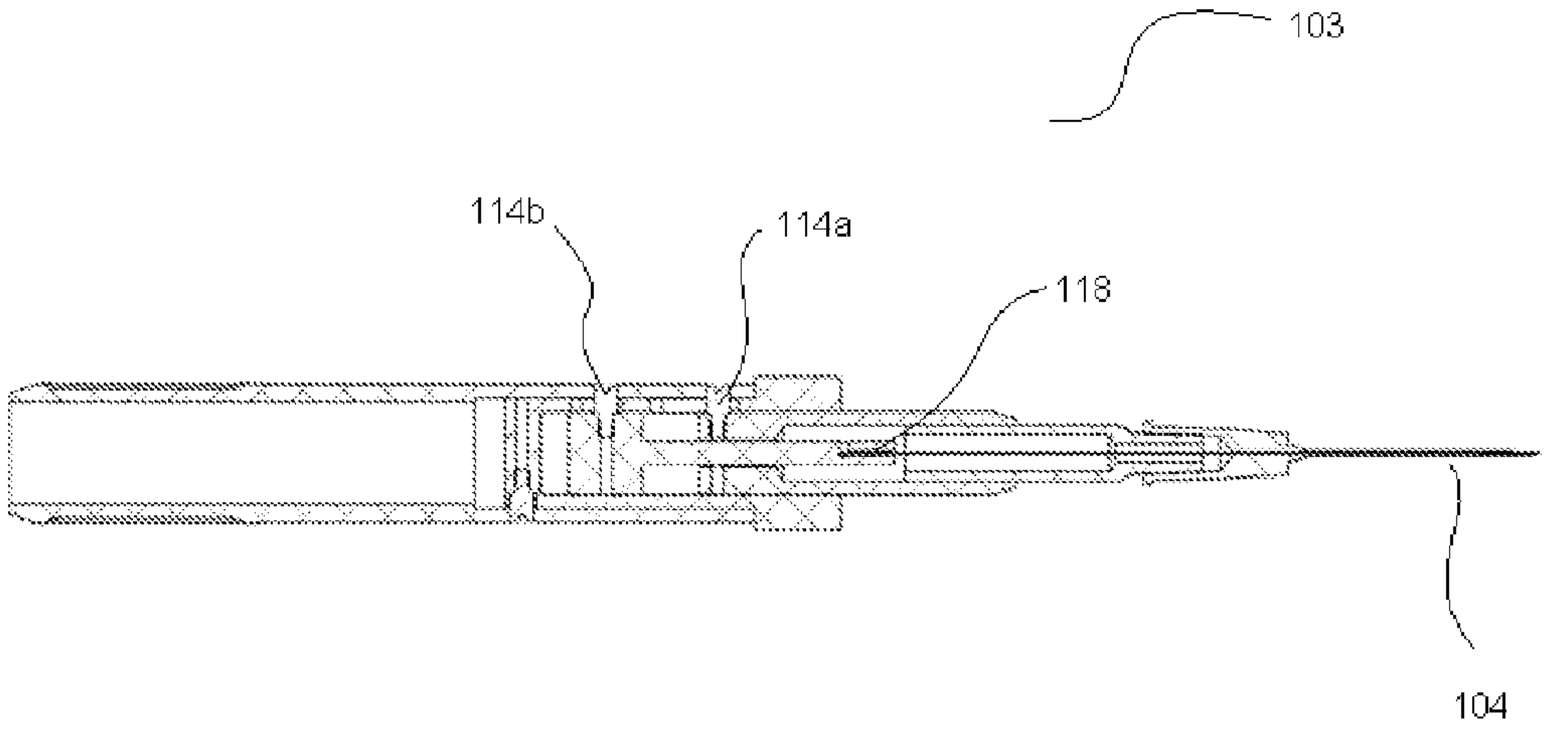

Figure 12 B

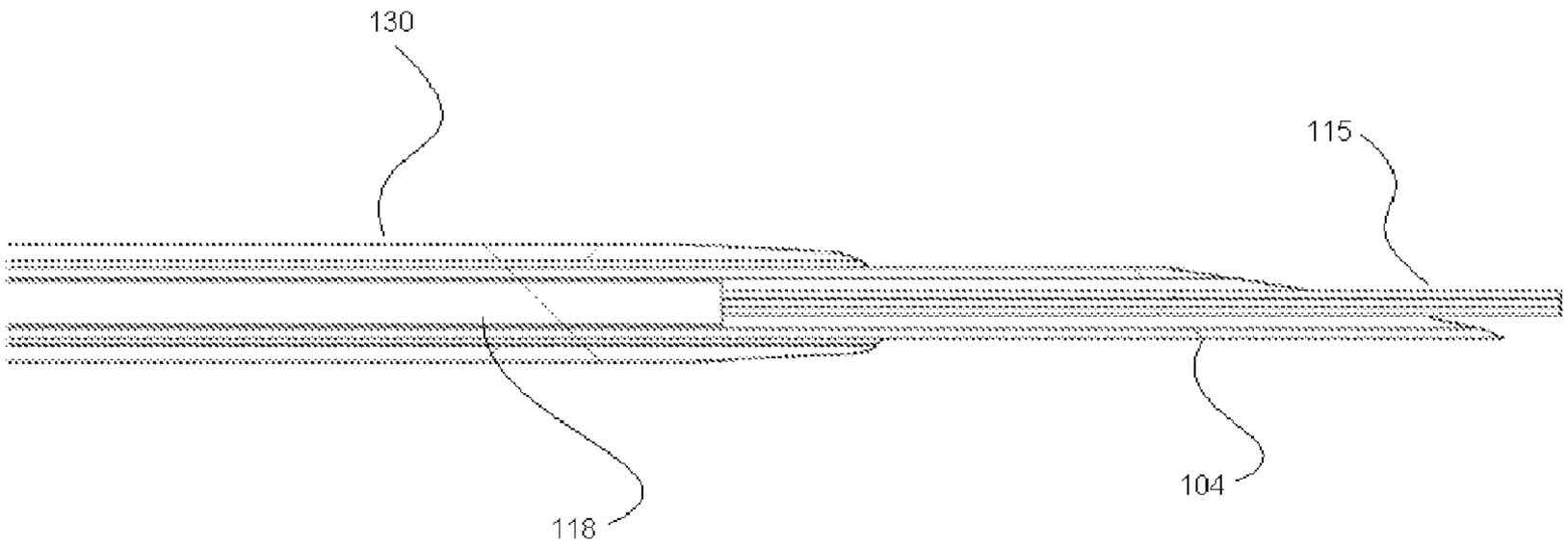

Figure 12C

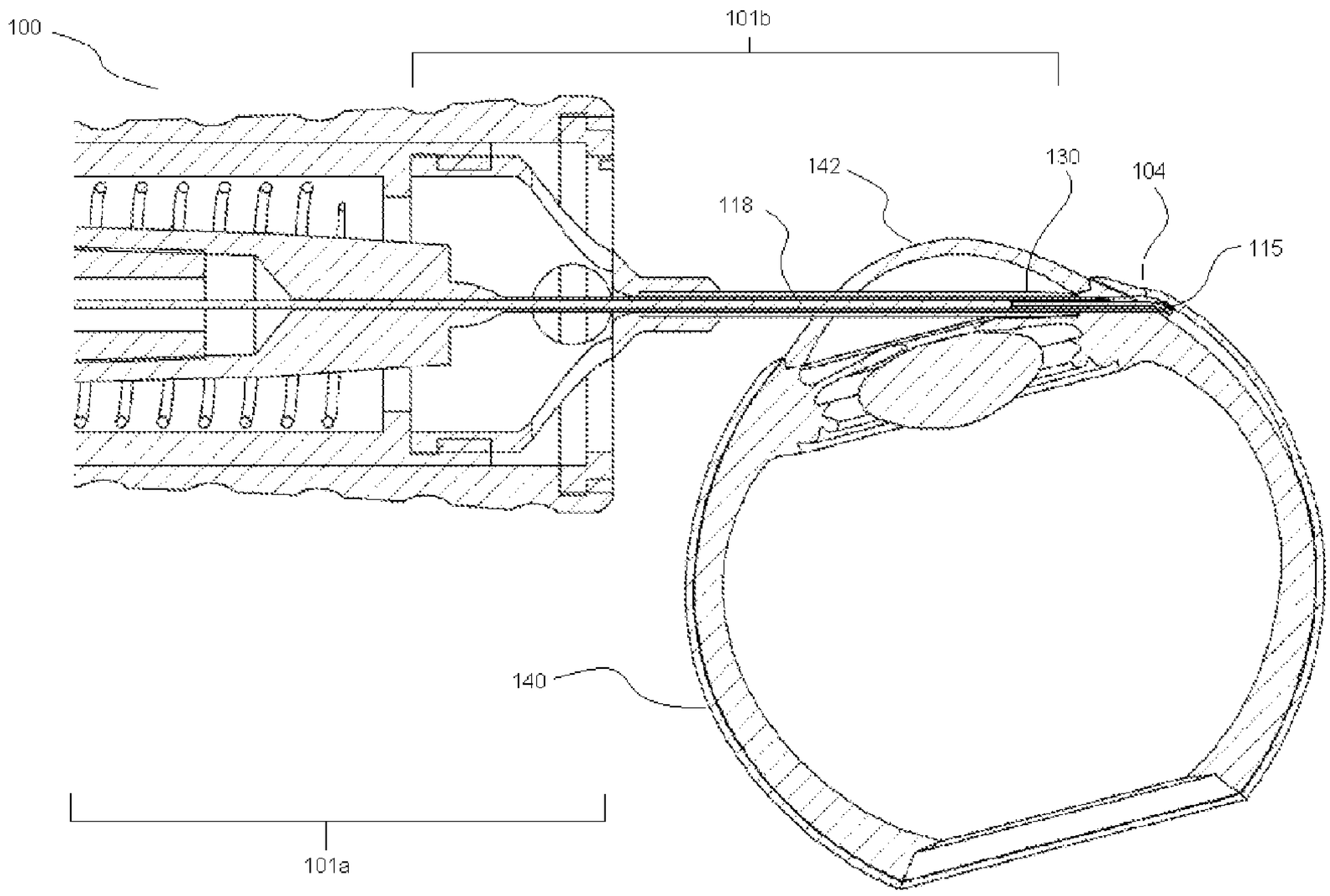

Figure 13

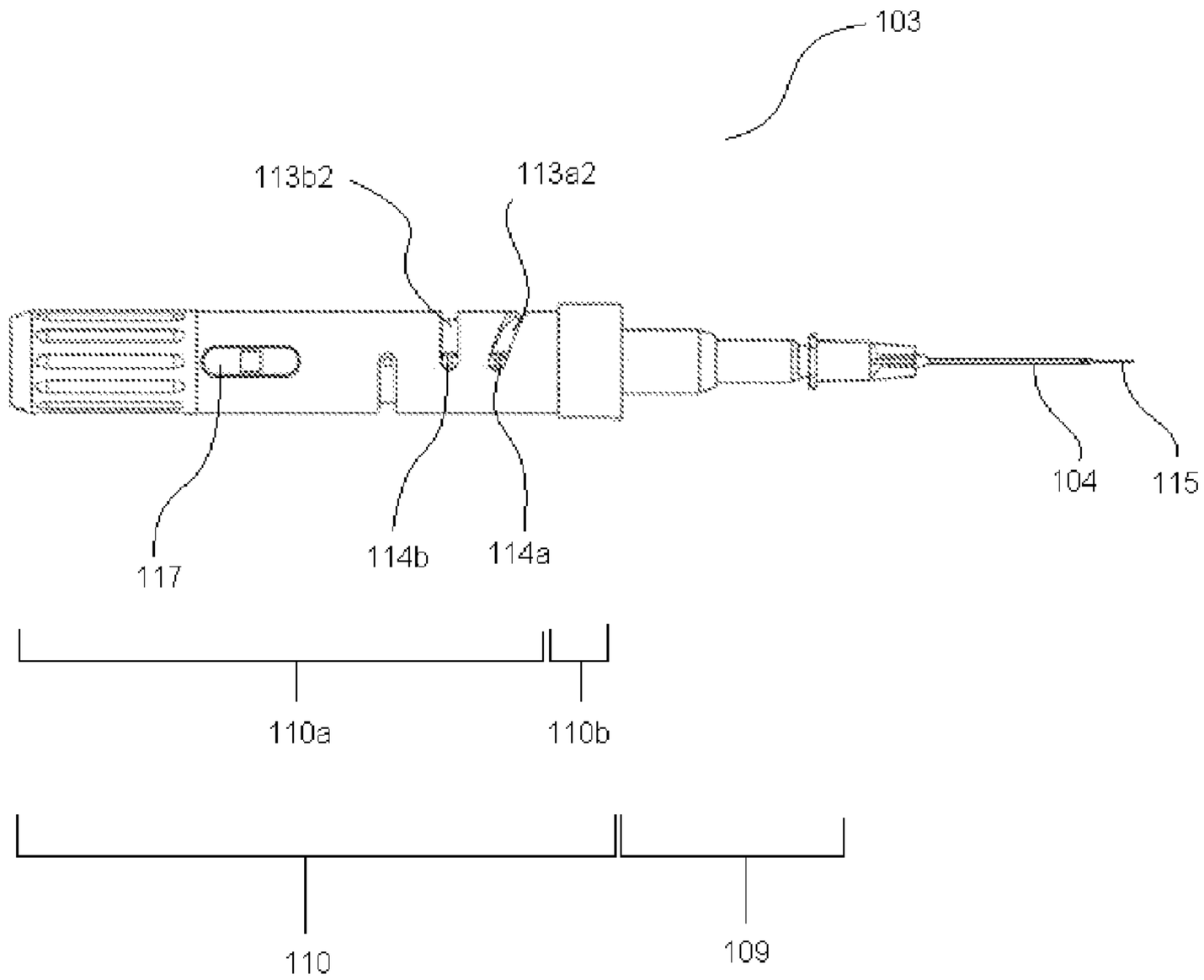

Figure 14A

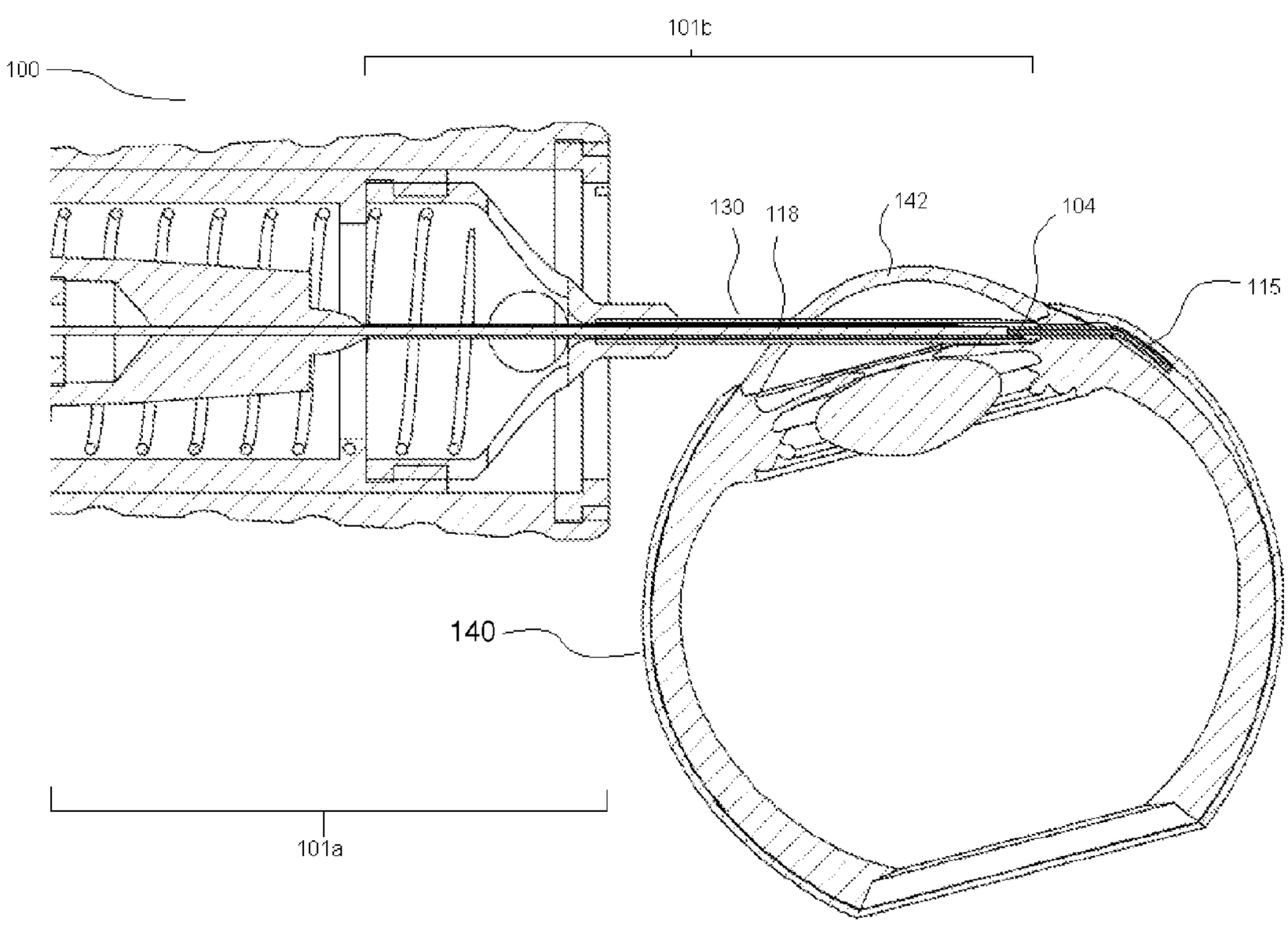

Figure 14B

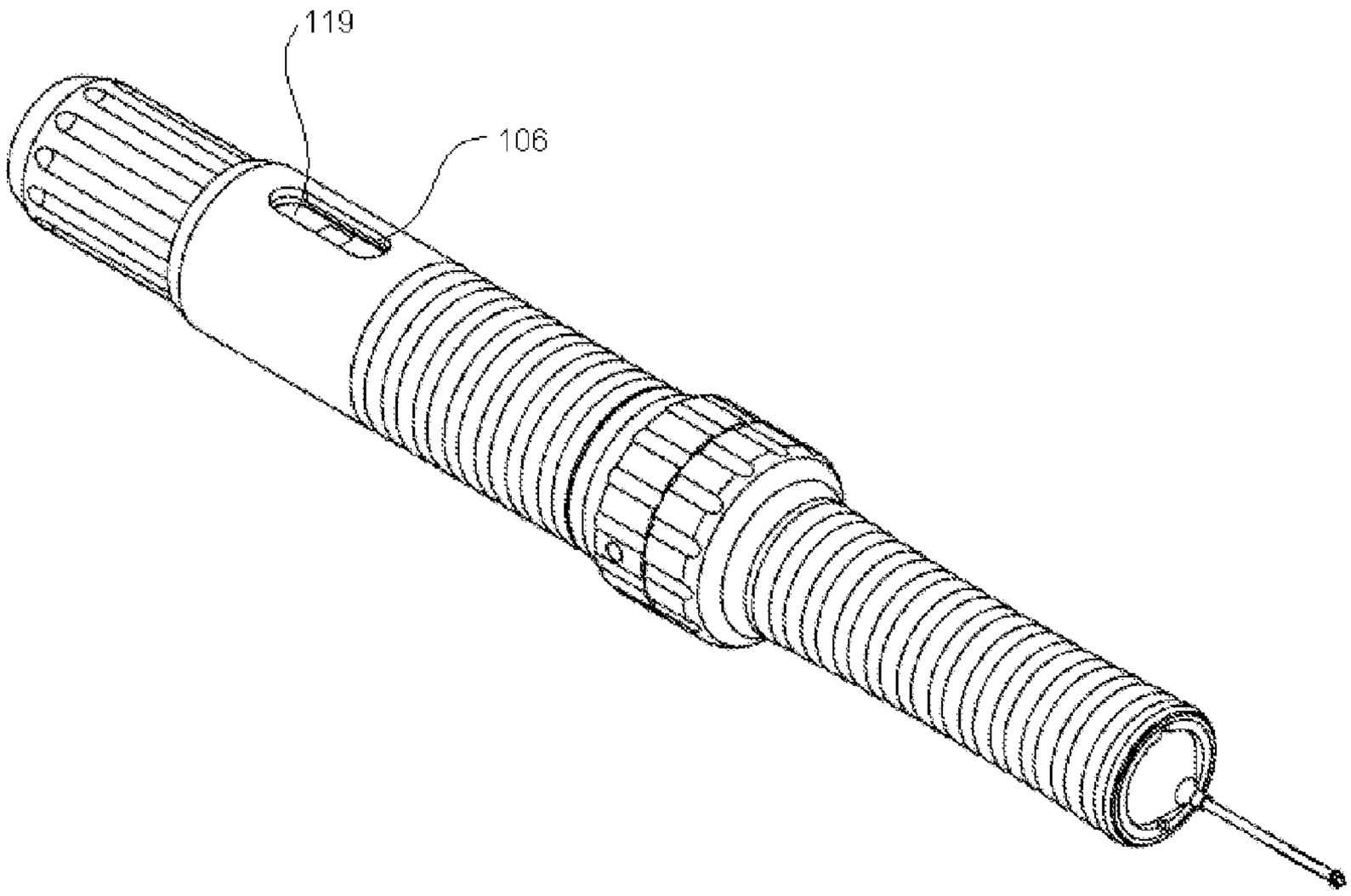

Figure 14C

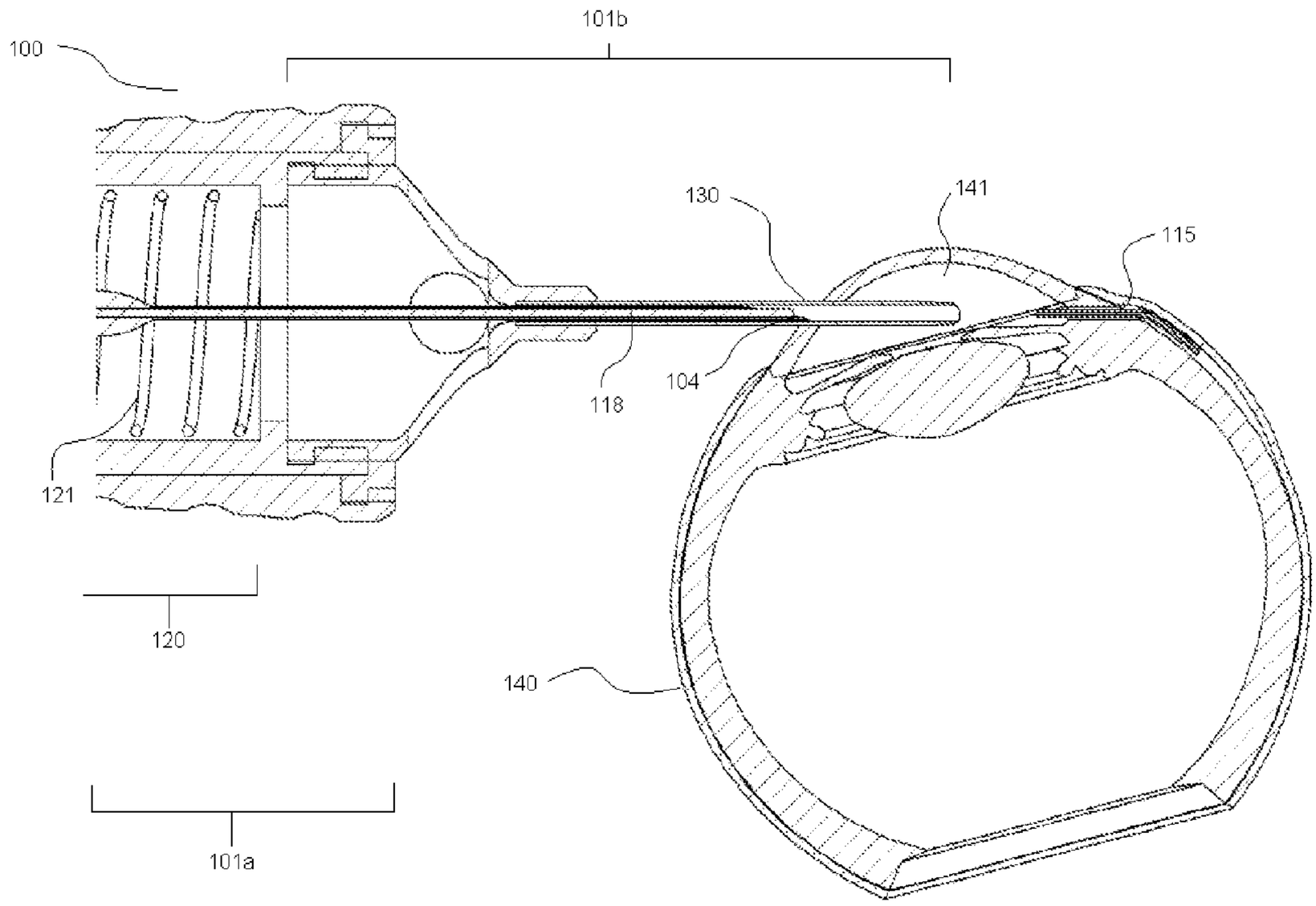

Figure 15

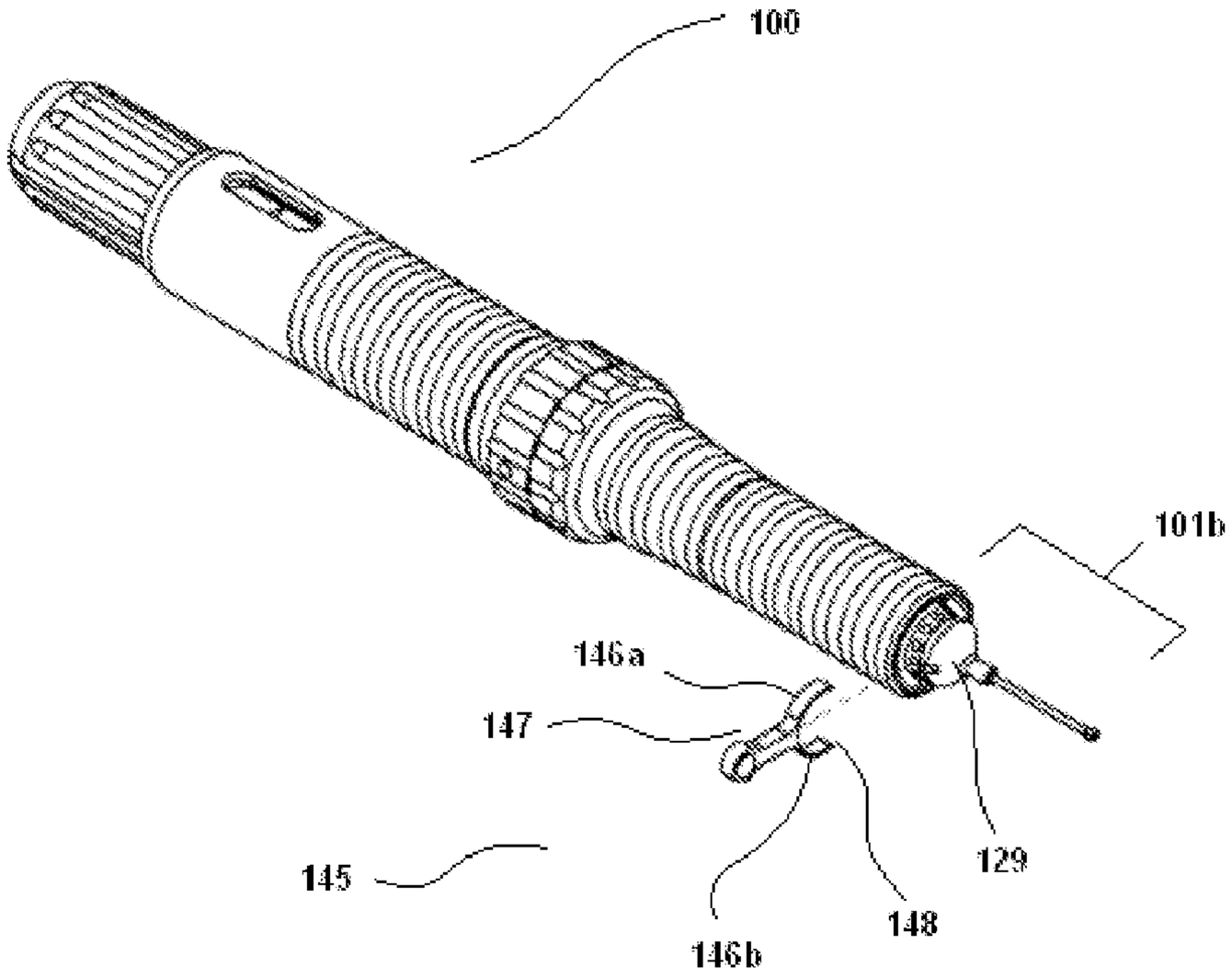

Figure 16A

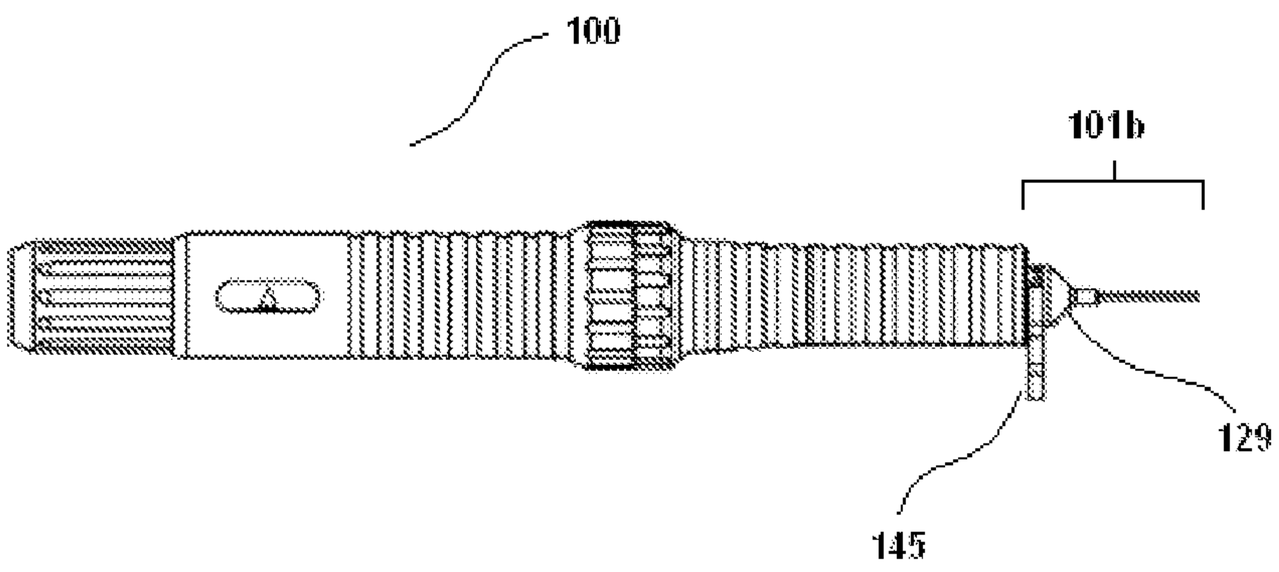

Figure 16B

SYSTEMS FOR DEPLOYING INTRAOCULAR SHUNTS

RELATED APPLICATION

The present application is a continuation-in-part of U.S. nonprovisional application Ser. No. 12/946,222, filed Nov. 15, 2010, the content of which is incorporated by reference herein in its entirety.

FIELD OF THE INVENTION

The present invention generally relates to systems for deploying intraocular shunts without the use of an optical apparatus that contacts an eye, such as a goniolens.

BACKGROUND

Glaucoma is a disease of the eye that affects millions of people. Glaucoma is associated with an increase in intraocular pressure resulting either from a failure of a drainage system of an eye to adequately remove aqueous humor from an anterior chamber of the eye or overproduction of aqueous humor by a ciliary body in the eye. Build-up of aqueous humor and resulting intraocular pressure may result in irreversible damage to the optic nerve and the retina, which may lead to irreversible retinal damage and blindness.

Glaucoma may be treated by surgical intervention that involves placing a shunt in the eye to result in production of fluid flow pathways between the anterior chamber and various structures of the eye involved in aqueous humor drainage (e.g., Schlemm's canal, the sclera, or the subconjunctival space). Such fluid flow pathways allow for aqueous humor to exit the anterior chamber. Generally, the surgical intervention to implant the shunt involves inserting into the eye a delivery device that holds an intraocular shunt, and deploying the shunt within the eye. A delivery device holding the shunt enters the eye through a cornea (ab interno approach), and is advanced across the anterior chamber. The delivery device is advanced through the sclera until a distal portion of the device is in proximity to a drainage structure of the eye. The shunt is then deployed from the delivery device, producing a conduit between the anterior chamber and various structures of the eye involved in aqueous humor drainage (e.g., Schlemm's canal, the sclera, or the subconjunctival space). See for example, Yu et al. (U.S. Pat. No. 6,544,249 and U.S. patent application number 2008/0108933) and Prywes (U.S. Pat. No. 6,007,511).

Such a surgical procedure requires an optical apparatus, such as a goniolens, so that a surgeon may visualize the delivery device within the eye and ensure proper placement of the shunt after it has been deployed from the delivery device.

SUMMARY

The present invention generally relates to systems and devices for deploying intraocular shunts from a delivery device without use of an optical apparatus that contacts the eye, preferably without use of any optical apparatus. Systems and devices of the invention accomplish shunt deployment without use of an optical apparatus by having a biased distal portion, such that upon entry of the distal portion of the device into an anterior chamber of an eye, the distal portion slides to fit within the anterior chamber angle of the eye. A resistance feedback feature of the device informs an operator that the deployment device is properly positioned within the anterior chamber angle of the eye for deployment and proper placement of the shunt within the eye.

In certain embodiments, devices of the invention include a housing having an angled distal end, a deployment mechanism at least partially disposed within the housing, and a hollow shaft coupled to the deployment mechanism, in which the shaft is configured to hold an intraocular shunt. Devices of the invention may further include an intraocular shunt that is at least partially disposed within the shaft. In particular embodiments, the angle of the distal end is substantially identical to an anterior chamber angle of an eye.

The housing of devices of the invention may include a proximal portion and a distal portion. In certain embodiments, the distal portion of the housing is movable within the proximal portion of the housing. The housing may further include a member that limits axial retraction of the distal portion of the housing. In certain embodiments, the distal portion includes a capsule and a sleeve. In other embodiments, a distal end of the sleeve further includes a protrusion. The protrusion may be formed integrally with the distal end of the sleeve or may be connected to a distal end of the sleeve. The protrusion may surround the distal end of the sleeve, or the protrusion may extend around only a portion of the sleeve. In certain embodiments, the protrusion is a collar that surrounds the distal end of the sleeve. In other embodiments, the protrusion includes a flat bottom portion and an angled top portion. In particular embodiments, the angle of the top portion is substantially identical to an anterior chamber angle of an eye.

Devices of the invention include numerous configurations, such as an insertion configuration, a shaft exposure configuration, and a deployment configuration. The insertion configuration includes the hollow shaft fully disposed within the sleeve. The shaft exposure configuration includes retraction of the capsule to at least partially within the proximal portion of the housing, thereby exposing a distal portion of the hollow shaft from the sleeve.

The deployment configuration involves engagement of the deployment mechanism. In certain embodiments, the deployment mechanism may include a two stage system. The first stage is a pusher component and the second stage is a retraction component. Rotation of the deployment mechanism sequentially engages the pusher component and then the retraction component. The pusher component pushes the shunt to partially deploy the shunt from within the shaft, and the retraction component retracts the shaft from around the shunt. The deployment mechanism further includes at least one member that limits axial movement of the shaft.

The hollow shaft of the deployment device may have various shapes and sizes. In certain embodiments, a distal end of the shaft is beveled. In particular embodiments, the bevel is a double bevel. In certain embodiments, the angle of the bevel is such that upon insertion of the shaft through the sclera of an eye, the bevel is substantially parallel with the conjunctiva of an eye. In certain embodiments, the hollow shaft is a needle.

Devices of the invention may be completely automated, partially automated, or completely manual. Devices of the invention may be connected to larger robotic systems or may be used as stand alone handheld deployment devices. In particular embodiments, the device is a handheld device.

Devices of the invention may include an indicator that provides feedback to an operator as to the state of the deployment mechanism. The indicator may be any type of indicator know in the art, for example a visual indicator, an audio indicator, or a tactile indicator. In certain embodiments, the indicator is a visual indicator.

Other aspects of the invention provide devices for deploying an intraocular shunt that include a housing, in which a distal end of the housing includes a protrusion, a deployment mechanism at least partially disposed within the housing, and a hollow shaft coupled to the deployment mechanism, in which the shaft is configured to hold an intraocular shunt. The devices may further include an intraocular shunt that is at least partially disposed within the shaft.

The housing of devices of the invention may include a proximal portion and a distal portion. In certain embodiments, the distal portion of the housing is movable within the proximal portion of the housing. The housing may further include a member that limits axial retraction of the distal portion of the housing. In certain embodiments, the distal portion includes a capsule and a sleeve. In other embodiments, a distal end of the sleeve further includes a protrusion. The protrusion may be formed integrally with the distal end of the sleeve or may be connected to a distal end of the sleeve. The protrusion may surround the distal end of the sleeve, or the protrusion may extend around only a portion of the sleeve. In certain embodiments, the protrusion is a collar that surrounds the distal end of the sleeve. In other embodiments, the protrusion includes a flat bottom portion and an angled top portion. In particular embodiments, the angle of the top portion is substantially identical to an anterior chamber angle of an eye.

Devices of the invention include numerous configurations, such as an insertion configuration, a shaft exposure configuration, and a deployment configuration. The insertion configuration includes the hollow shaft fully disposed within the sleeve. The shaft exposure configuration includes retraction of the capsule to at least partially within the proximal portion of the housing, thereby exposing a distal portion of the hollow shaft from the sleeve.

The deployment configuration involves engagement of the deployment mechanism. In certain embodiments, the deployment mechanism may include a two stage system. The first stage is a pusher component and the second stage is a retraction component. Rotation of the deployment mechanism sequentially engages the pusher component and then the retraction component. The pusher component pushes the shunt to partially deploy the shunt from within the shaft, and the retraction component retracts the shaft from around the shunt. The deployment mechanism further includes at least one member that limits axial movement of the shaft.

The hollow shaft of the deployment device may have various shapes and sizes. In certain embodiments, a distal end of the shaft is beveled. In particular embodiments, the bevel is a double bevel. In certain embodiments, the angle of the bevel is such that upon insertion of the shaft through the sclera of an eye, the bevel is substantially parallel with the conjunctiva of an eye. In certain embodiments, the hollow shaft is a needle.

Devices of the invention may be completely automated, partially automated, or completely manual. Devices of the invention may be connected to larger robotic systems or may be used as stand alone handheld deployment devices. In particular embodiments, the device is a handheld device.

Devices of the invention may include an indicator that provides feedback to an operator as to the state of the deployment mechanism. The indicator may be any type of indicator know in the art, for example a visual indicator, an audio indicator, or a tactile indicator. In certain embodiments, the indicator is a visual indicator.

Another aspect of the invention provides devices for deploying an intraocular shunt that include a deployment mechanism, a hollow shaft coupled to the deployment mechanism and configured to hold an intraocular shunt, and a member adapted to provide resistance feedback to an operator upon a distal portion of the device contacting an anatomical feature of the eye, such as the sclera. The resistance feedback indicates to an operator that a distal portion of the device is properly positioned to deploy the shunt.

Another aspect of the invention provides devices for deploying an intraocular shunt that include a deployment mechanism, a hollow shaft coupled to the deployment mechanism and configured to hold an intraocular shunt, and means for providing feedback to an operator advancing the shaft. The feedback indicates to an operator that a distal portion of the shaft is properly positioned to deploy the shunt. In certain embodiments, the feedback is resistance feedback.

Other aspects of the invention provide devices for deploying an intraocular shunt including a housing having a proximal portion and a distal portion, in which the distal portion is movable within the proximal portion, a deployment mechanism at least partially disposed within the housing, and a hollow shaft coupled to the deployment mechanism, in which the shaft is configured to hold an intraocular shunt. The devices may further include an intraocular shunt that is at least partially disposed within the shaft. The housing may further include a member that limits axial retraction of the distal portion of the housing.

In certain embodiments, the distal portion includes a capsule and a sleeve. In other embodiments, a distal end of the sleeve further includes a protrusion. The protrusion may be formed integrally with the distal end of the sleeve or may be connected to a distal end of the sleeve. The protrusion may surround the distal end of the sleeve, or the protrusion may extend around only a portion of the sleeve. In certain embodiments, the protrusion is a collar that surrounds the distal end of the sleeve. In other embodiments, the protrusion includes a flat bottom portion and an angled top portion. In particular embodiments, the angle of the top portion is substantially identical to an anterior chamber angle of an eye.

Devices of the invention include numerous configurations, such as an insertion configuration, a shaft exposure configuration, and a deployment configuration. The insertion configuration includes the hollow shaft fully disposed within the sleeve. The shaft exposure configuration includes retraction of the capsule to at least partially within the proximal portion of the housing, thereby exposing a distal portion of the hollow shaft from the sleeve.

The deployment configuration involves engagement of the deployment mechanism. In certain embodiments, the deployment mechanism may include a two stage system. The first stage is a pusher component and the second stage is a retraction component. Rotation of the deployment mechanism sequentially engages the pusher component and then the retraction component. The pusher component pushes the shunt to partially deploy the shunt from within the shaft, and the retraction component retracts the shaft from around the shunt. The deployment mechanism further includes at least one member that limits axial movement of the shaft.

The hollow shaft of the deployment device may have various shapes and sizes. In certain embodiments, a distal end of the shaft is beveled. In particular embodiments, the bevel is a double bevel. In certain embodiments, the angle of the bevel is such that upon insertion of the shaft through the sclera of an eye, the bevel is substantially parallel with the conjunctiva of an eye. In certain embodiments, the hollow shaft is a needle.

Devices of the invention may be completely automated, partially automated, or completely manual. Devices of the invention may be connected to larger robotic systems or may be used as stand alone handheld deployment devices. In particular embodiments, the device is a handheld device.

Devices of the invention may include an indicator that provides feedback to an operator as to the state of the deployment mechanism. The indicator may be any type of indicator know in the art, for example a visual indicator, an audio indicator, or a tactile indicator. In certain embodiments, the indicator is a visual indicator.

Other aspects of the invention provide devices for deploying an intraocular shunt including a housing, a deployment mechanism at least partially disposed within the housing, and a hollow shaft coupled inside the housing to the deployment mechanism, in which the shaft is configured to hold an intraocular shunt. These devices include an insertion configuration and a deployment configuration and the insertion configuration involves the shaft being fully disposed within the housing. The devices may further include an intraocular shunt that is at least partially disposed within the shaft.

The housing of devices of the invention may include a proximal portion and a distal portion. In certain embodiments, the distal portion of the housing is movable within the proximal portion of the housing. The housing may further include a member that limits axial retraction of the distal portion of the housing. In certain embodiments, the distal portion includes a capsule and a sleeve. In other embodiments, a distal end of the sleeve further includes a protrusion. The protrusion may be formed integrally with the distal end of the sleeve or may be connected to a distal end of the sleeve. The protrusion may surround the distal end of the sleeve, or the protrusion may extend around only a portion of the sleeve. In certain embodiments, the protrusion is a collar that surrounds the distal end of the sleeve. In other embodiments, the protrusion includes a flat bottom portion and an angled top portion. In particular embodiments, the angle of the top portion is substantially identical to an anterior chamber angle of an eye.

Devices of the invention also include a shaft exposure configuration. The shaft exposure configuration includes retraction of the capsule to at least partially within the proximal portion of the housing, thereby exposing a distal portion of the hollow shaft from the sleeve. The deployment configuration involves engagement of the deployment mechanism. In certain embodiments, the deployment mechanism may include a two stage system. The first stage is a pusher component and the second stage is a retraction component. Rotation of the deployment mechanism sequentially engages the pusher component and then the retraction component. The pusher component pushes the shunt to partially deploy the shunt from within the shaft, and the retraction component retracts the shaft from around the shunt. The deployment mechanism further includes at least one member that limits axial movement of the shaft.

The hollow shaft of the deployment device may have various shapes and sizes. In certain embodiments, a distal end of the shaft is beveled. In particular embodiments, the bevel is a double bevel. In certain embodiments, the angle of the bevel is such that upon insertion of the shaft through the sclera of an eye, the bevel is substantially parallel with the conjunctiva of an eye. In certain embodiments, the hollow shaft is a needle.

Devices of the invention may be completely automated, partially automated, or completely manual. Devices of the invention may be connected to larger robotic systems or may be used as stand alone handheld deployment devices. In particular embodiments, the device is a handheld device.

Devices of the invention may include an indicator that provides feedback to an operator as to the state of the deployment mechanism. The indicator may be any type of indicator know in the art, for example a visual indicator, an audio indicator, or a tactile indicator. In certain embodiments, the indicator is a visual indicator.

Other aspects of the invention provide systems for deploying an intraocular shunt that include a locking mechanism, and a device configured to hold and deploy an intraocular shunt, in which a distal portion of the device is movable within a proximal portion of the device and the distal portion of the device is configured to mate with the locking mechanism to prevent movement of the distal portion when the locking mechanism is engaged. In certain embodiments, the locking mechanism is configured to fit at least partially around the distal portion of the device. In other embodiments, the locking mechanism includes teeth that mate with holes in the distal portion of the device.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a schematic showing an embodiment of a shunt deployment device according to the invention. FIG. **1**B shows a cross sectional view of the device of FIG. **1**. In this figure, the distal portion of the housing is extended from the proximal portion of the housing. FIG. **1**C shows a cross sectional view of the device of FIG. **1**. In this figure, the distal portion of the housing is retracted within the proximal portion of the housing. FIG. **1**D is a schematic showing an enlarged view of a protrusion on a distal end of a distal portion of a housing of the device of FIG. **1**A. In this figure, a bottom portion of the protrusion is flat and a top portion of the protrusion is angled.

FIGS. **2**A-**2**C are schematics showing an enlarged view of a protrusion on a distal end of a distal portion of a housing of devices of the invention. FIG. **2**B is a side view of the protrusion shown in FIG. **2**A. FIG. **2**C is a top view of the protrusion shown in FIG. **2**A.

FIG. **3**A shows a deployment device in an insertion configuration and fit into an anterior chamber of an eye. FIG. **3**B shows a deployment device in an insertion configuration and inserted at too shallow an angled, thus abutting the sclera above the anterior chamber angle. FIG. **3**C shows a deployment device in an insertion configuration after the protrusion has caused the device to slide down the sclera and be fit into an anterior chamber of an eye. FIG. **3**D shows a deployment device in an insertion configuration and inserted at too steep an angled, thus abutting the iris below the anterior chamber angle. FIG. **3**E shows a deployment device in an insertion configuration after the protrusion has caused the device to deflect off of the iris and slide along the iris and be fit into an anterior chamber of an eye.

FIG. **4** shows an exploded view of the device shown in FIG. **1**.

FIGS. **5**A to **5**D are schematics showing different enlarged views of the deployment mechanism of the deployment device.

FIGS. **6**A to **6**C are schematics showing interaction of the deployment mechanism with a portion of the housing of the deployment device.

FIG. **7** depicts a schematic of an exemplary intraocular shunt.

FIG. **8** shows a cross sectional view of the deployment mechanism of the deployment device.

FIG. **9**A is a schematic showing deployment devices of the invention in a pre-deployment or insertion configuration. FIG. **9**B shows an enlarged view of the distal portion of the deployment device of FIG. **9**A. This figure shows an intraocular shunt loaded within a hollow shaft of the deployment device and that the shaft is completely disposed within the sleeve of the housing. FIG. **9**C show a schematic of the

deployment mechanism in a pre-deployment or insertion configuration. FIG. **9**D is another schematic showing deployment devices of the invention in a pre-deployment or insertion configuration.

FIG. **10** is a schematic showing insertion of a device of the invention into an anterior chamber of the eye. This figure also shows the sleeve and protrusion fitted within an anterior chamber angle of the eye.

FIG. **11** is a schematic showing extension of the shaft from within the sleeve, which is accomplished by partial retraction of the distal portion of housing to within the proximal portion of housing.

FIGS. **12**A and **12**B show schematics of the deployment mechanism at the end of the first stage of deployment of the shunt from the deployment device. FIG. **12**C shows an enlarged view of the distal portion of the deployment device of FIG. **12**A. This figure shows an intraocular shunt partially deployed from within a hollow shaft of the deployment device.

FIG. **13** is a schematic showing the deployment device after completion of the first stage of deployment of the shunt from the device and in to the eye.

FIG. **14**A show a schematic of the deployment mechanism at the end of the second stage of deployment. FIG. **14**B shows a schematic of the deployment device at the end of the second stage of deployment. FIG. **14**C shows another view of the deployment device at the end of the second stage of deployment.

FIG. **15** is a schematic showing the deployment device after completion of deployment of the shunt from the device and in to the eye.

FIGS. **16**A and B are schematics showing a deployment device of the invention and a locking mechanism. FIG. **16**A shows the locking mechanism prior to attachment to the deployment device. FIG. **16**B shows the locking mechanism engaged with the deployment device

DETAILED DESCRIPTION

Reference is now made to FIG. **1**A which shows an embodiment of a shunt deployment device **100** according to the invention. While FIG. **1** shows a handheld manually operated shunt deployment device, it will be appreciated that devices of the invention may be coupled with robotic systems and may be completely or partially automated. As shown in FIG. **1**A deployment device **100** includes a generally cylindrical body or housing **101**, however, the body shape of housing **101** could be other than cylindrical. Housing **101** may have an ergonomical shape, allowing for comfortable grasping by an operator. Housing **101** is shown with optional grooves **102** to allow for easier gripping by a surgeon.

FIG. **1**B shows a cross sectional view of device **100**. This figure shows that housing **101** includes a proximal portion **101***a* and a distal portion **101***b*. The distal portion **101***b* is movable within proximal portion **101***a*. In this figure, spring mechanism **120** includes a spring **121** that controls movement of distal portion **101***b*. Spring mechanism **120** further includes a member **122** that acts as a stopper and limits axial retraction of distal portion **101***b* within proximal portion **101***a*. Spring mechanism **120** further includes members **123** and **124** that run the length of spring **121**. The ends of members **123** and **124** include flanges **125** and **126** that project inward from members **123** and **124**. An end of distal portion **101***b* includes flanges **127** and **128** that project outward from distal portion **101***b*. Flanges **125** and **126** interact with flanges **127** and **128** to prevent release of distal portion **101***b* from proximal portion **101***a*. The flanges **125** and **126** and **127** and **128** hold the distal portion **101***b* in an extended position until a compressive force acts upon distal portion **101***b*, thereby causing distal portion **101***b* to partially retract within proximal portion **101***a*.

Distal portion **101***b* includes a capsule **129** and a hollow sleeve **130**. Capsule **129** and sleeve **130** may be formed integrally or may be separate components that are coupled or connected to each other. The hollow sleeve **130** is configured for insertion into an eye and to extend into an anterior chamber of an eye. FIG. **1**B shows distal portion **101***b* of housing **101** extended from proximal portion **101***a* of housing **101**. In this configuration, hollow shaft **104** (not shown in this figure) is completely disposed within sleeve **130**. FIG. **1**C shows distal portion **101***b* of housing **101** retracted within proximal portion **101***a* of housing **101**. Retraction of distal portion **101***b* of housing **101** within proximal portion **101***a* of housing **101** exposes hollow shaft **104**, which is discussed in greater detail below.

Devices of the invention may be configured to mate with a locking mechanism **145**, as shown in FIGS. **16**A and B, in order to prevent movement of the distal portion **101***b* when the locking mechanism **145** is engaged. FIG. **16**A shows an exemplary locking mechanism **145**. FIG. **16**B showing the locking mechanism **145** engaged with a distal portion **101***b* of device **100**. In this embodiment, the locking mechanism is configured to fit at least partially around the distal portion **101***b* of the device **100**. However, other configures are possible, for example, a locking mechanism that is a closed loop that slides over the distal portion **101***b* to thereby engage the distal portion **101***b*.

The locking mechanism **145** may be made of any shape memory material, such as Nitinol, or of any commercially available resilient plastic or polymer. The locking mechanism is biased toward the closed position. The locking mechanism **145** includes an upper curved portion **146***a* and a lower curved portion **146***b*. The curved portions are joined by a stem-loop portion **147**. The distal end of each of the upper and lower curved portions **146***a* and **146***b* may include a tooth or teeth **148**. The teeth **148** are configured to engage holes in the distal portion **101***b* of device **100**. In particular embodiments, the teeth **148** engage holes in the capsule **129**, as shown in FIGS. **16**A and B.

In operation, a compressive force is applied to the stem-loop portion **147**, thus expanding the space between the upper curved portion **146***a* and the lower curved portion **146***b* such that the locking mechanism **145** can engage the distal portion **101***b* of the device **100**. Once in the proper position, the compressive form is released from the stem-loop portion **147**, causing the upper curved portion **146***a* and a lower curved portion **146***b* to move toward each other and engage the distal portion **101***b* of the device **100**. Teeth **148** interact with the holes in the capsule **129** and secure the locking mechanism **145** to the distal portion **101***b* of the device **100**. Once secured, the locking mechanism **145** prevents movement of the distal portion **101***b* of the device **100**.

A distal end of sleeve **130** includes a protrusion **131** (FIG. **1**D). Protrusion **131** provides resistance feedback to an operator as the operator is advancing the sleeve **130** through an anterior chamber of an eye. In a standard ab interno approach (see for example Yu et al. U.S. Pat. No. 6,544,249 and U.S. patent application number 2008/0108933) a deployment device holding a shunt enters an eye through a cornea. The deployment device is advanced across the anterior chamber in what is referred to as a transpupil implant insertion. The deployment device is advanced to the sclera on the opposite side of the eye from which the device entered the eye. With devices of the invention, upon advancement of the device **100**

across an anterior chamber of the eye, the protrusion **131** at the distal end of the hollow sleeve **130** will contact the sclera, providing resistance feedback to an operator that no further advancement of the device **100** is necessary. This feedback also informs the operator that the device **100** is in proper position for exposure of the hollow shaft **104**, which will advance through the sclera for deployment of an intraocular shunt. The protrusion **131**, provides adequate surface area at the distal end of sleeve **130**, thus preventing sleeve **130** from entering the sclera.

In certain embodiments, protrusion **131** has a substantially flat bottom portion and an angled top portion (FIG. **1**D). In other embodiments, protrusion **131** has a slightly tapered top and a slightly tapered bottom with a rounded distal portion (FIGS. **2**A-**2**C).

Referring back to FIG. **1**D, the angle of the top portion is substantially identical to an anterior chamber angle of an eye. Such a shape of the protrusion ensures that the device of the invention will also finds its way to fit into the anterior chamber angle of the eye, the place for proper deployment of an intraocular shunt. This is explained with reference to FIGS. **3**A to **3**E. FIG. **3**A shows device **100** in an insertion configuration and inserted into an eye **140**. In this figure, protrusion **131** at the distal end of the sleeve **130** has been advanced across the anterior chamber **141** to the sclera **142** on the opposite side of the eye **140** from which the device entered the eye **140**. FIG. **3**A shows protrusion **131** fitted within the anterior chamber angle **143** of the eye **140**. If sleeve **130** enters the anterior chamber **141** at too shallow an angle, i.e., the protrusion **131** hit the sclera **142** above the anterior chamber angle **143**, the angled top portion of the protrusion **131** causes the sleeve **130** to slide down the sclera **142** (direction of arrow) until the protrusion **131** is fit within the anterior chamber angle **143** of the eye **140** (FIGS. **3**B and **3**C). The sleeve **130** will slide down the sclera **142** instead of entering the sclera **142** at the contact point because the shaft **104** is completely disposed within the sleeve **130** and the protrusion **131** provides adequate surface area at the distal end of sleeve **130** to prevent enough force from being generated at the distal end of sleeve **130** that would result in sleeve **130** entering the sclera **142**.

Conversely, if sleeve **130** enters the anterior chamber **141** at too steep an angle, i.e., the protrusion **131** hit the iris **144** below the anterior chamber angle **143**, the substantially flat bottom portion of the protrusion **131** causes the sleeve **130** to deflect off the iris **144** and proceed is a direction parallel to the iris **144** until the protrusion **131** is fit within the anterior chamber angle **143** of the eye **140** (FIGS. **3**D and **3**E). The sleeve **130** will deflect off the iris **144** instead of entering the iris **144** at the contact point because the shaft **104** is completely disposed within the sleeve **130** and the protrusion **131** provides adequate surface area at the distal end of sleeve **130** to prevent enough force from being generated at the distal end of sleeve **130** that would result in sleeve **130** entering the iris **144**.

In certain embodiments, protrusion **131** is not required. In these embodiments, the sleeve **130** is of a sufficient outer diameter such that the sleeve itself may serve the function of the protrusion as described above. In these embodiments, a distal end of the sleeve is shaped to have a flat bottom portion and an angled top portion.

Referring back to FIG. **1**A, the proximal portion **101***a* of the housing **101** is open at its proximal end, such that a portion of a deployment mechanism **103** may extend from the proximal end of the proximal portion **101***a* of the housing **101**. The sleeve **130** of the distal portion **101***b* of the housing **101** is also open such that at least a portion of a hollow shaft **104** may extend inside the housing, into sleeve **130** of the distal portion **101***b* of the housing **101**, and extend beyond the distal end of the sleeve **130** in certain configurations (such as the deployment configuration). Housing **101** further includes a slot **106** through which an operator, such as a surgeon, using the device **100** may view an indicator **107** on the deployment mechanism **103**.

Housing **101** and protrusion **131** may be made of any material that is suitable for use in medical devices. For example, housing **101** and protrusion **131** may be made of a lightweight aluminum or a biocompatible plastic material. Examples of such suitable plastic materials include polycarbonate and other polymeric resins such as DELRIN and ULTEM. In certain embodiments, housing **101** and protrusion **131** are made of a material that may be autoclaved, and thus allow for housing **101** and protrusion **131** to be re-usable. Alternatively, device **100**, may be sold as a one-time-use device, and thus the material of the housing and the protrusion does not need to be a material that is autoclavable.

The proximal portion **101***a* of housing **101** may be made of multiple components that connect together to form the housing. FIG. **4** shows an exploded view of deployment device **100**. In this figure, proximal portion **101***a* of housing **101**, is shown having two components **101***a***1** and **101***a***2**. The components are designed to screw together to form proximal portion **101***a* of housing **101**. FIG. **5** also shows deployment mechanism **103**. The housing **101** is designed such that deployment mechanism **103** fits within assembled housing **101**. Housing **101** is designed such that components of deployment mechanism **103** are movable within housing **101**.

FIGS. **5**A to **5**D show different enlarged views of the deployment mechanism **103**. Deployment mechanism **103** may be made of any material that is suitable for use in medical devices. For example, deployment mechanism **103** may be made of a lightweight aluminum or a biocompatible plastic material. Examples of such suitable plastic materials include polycarbonate and other polymeric resins such as DELRIN and ULTEM. In certain embodiments, deployment mechanism **103** is made of a material that may be autoclaved, and thus allow for deployment mechanism **103** to be re-usable. Alternatively, device **100** may be sold as a one-time-use device, and thus the material of the deployment mechanism does not need to be a material that is autoclavable.

Deployment mechanism **103** includes a distal portion **109** and a proximal portion **110**. The deployment mechanism **103** is configured such that distal portion **109** is movable within proximal portion **110**. More particularly, distal portion **109** is capable of partially retracting to within proximal portion **110**.

In this embodiment, the distal portion **109** is shown to taper to a connection with a hollow shaft **104**. This embodiment is illustrated such that the connection between the hollow shaft **104** and the distal portion **109** of the deployment mechanism **103** occurs inside the housing **101**. Hollow shaft **104** may be removable from the distal portion **109** of the deployment mechanism **103**. Alternatively, the hollow shaft **104** may be permanently coupled to the distal portion **109** of the deployment mechanism **103**.

Generally, hollow shaft **104** is configured to hold an intraocular shunt **115**. An exemplary intraocular shunt **115** in shown in FIG. **7**. Other exemplary intraocular shunts are shown in Yu et al. (U.S. patent application number 2008/0108933). Generally, in one embodiment, intraocular shunts are of a cylindrical shape and have an outside cylindrical wall and a hollow interior. The shunt may have an inner diameter of approximately 50 μm to approximately 250 μm, an outside diameter of approximately 80 μm to approximately 300 μm, and a length of approximately 0.5 mm to about 20 mm. Thus,

hollow shaft **104** is configured to at least hold a shunt of such shape and such dimensions. However, hollow shaft **104** may be configured to hold shunts of different shapes and different dimensions than those described above, and the invention encompasses a shaft **104** that may be configured to hold any shaped or dimensioned intraocular shunt. In particular embodiments, the shaft has an inner diameter of approximately 200 μm to approximately 400 μm.

The shaft **104** may be any length. A usable length of the shaft may be anywhere from about 5 mm to about 40 mm, and is 15 mm in certain embodiments. In certain embodiments, the shaft is straight. In other embodiments, shaft **104** is of a shape other than straight, for example a shaft having a bend along its length or a shaft having an arcuate portion. Exemplary shaped shafts are shown for example in Yu et al. (U.S. patent application number 2008/0108933). In particular embodiments, the shaft includes a bend at a distal portion of the shaft. In other embodiments, a distal end of the shaft is beveled or is sharpened to a point.

The shaft **104** may hold the shunt at least partially within the hollow interior of the shaft **104**. In other embodiments, the shunt is held completely within the hollow interior of the shaft **104**. Alternatively, the hollow shaft may hold the shunt on an outer surface of the shaft **104**. In particular embodiments, the shunt is held within the hollow interior of the shaft **104**. In certain embodiments, the hollow shaft is a needle having a hollow interior. Needles that are configured to hold an intraocular shunt are commercially available from Terumo Medical Corp. (Elkington, Md.).

A proximal portion of the deployment mechanism **103** includes optional grooves **116** to allow for easier gripping by an operator for easier rotation of the deployment mechanism, which will be discussed in more detail below. The proximal portion **110** of the deployment mechanism also includes at least one indicator that provides feedback to an operator as to the state of the deployment mechanism. The indicator may be any type of indicator known in the art, for example a visual indicator, an audio indicator, or a tactile indicator. FIG. **5** shows a deployment mechanism having two indicators, a ready indicator **111** and a deployed indicator **119**. Ready indicator **111** provides feedback to an operator that the deployment mechanism is in a configuration for deployment of an intraocular shunt from the deployment device **100**. The indicator **111** is shown in this embodiment as a green oval having a triangle within the oval. Deployed indicator **119** provides feedback to the operator that the deployment mechanism has been fully engaged and has deployed the shunt from the deployment device **100**. The deployed indicator **119** is shown in this embodiment as a yellow oval having a black square within the oval. The indicators are located on the deployment mechanism such that when assembled, the indicators **111** and **119** may be seen through slot **106** in housing **101**.

The proximal portion **110** includes a stationary portion **110***b* and a rotating portion **110***a*. The proximal portion **110** includes a channel **112** that runs part of the length of stationary portion **110***b* and the entire length of rotating portion **110***a*. The channel **112** is configured to interact with a protrusion **117** on an interior portion of housing component **101***a* (FIGS. **6**A and **6**B). During assembly, the protrusion **117** on housing component **101***a***1** is aligned with channel **112** on the stationary portion **110***b* and rotating portion **110***a* of the deployment mechanism **103**. The proximal portion **110** of deployment mechanism **103** is slid within housing component **101***a***1** until the protrusion **117** sits within stationary portion **110***b* (FIG. **6**C). Assembled, the protrusion **117** interacts with the stationary portion **110***b* of the deployment mechanism **103** and prevents rotation of stationary portion **110***b*. In this configuration, rotating portion **110***a* is free to rotate within housing component **101***a***1**.

Referring back to FIG. **5**, the rotating portion **110***a* of proximal portion **110** of deployment mechanism **103** also includes channels **113***a*, **113***b*, and **113***c*. Channel **113***a* includes a first portion **113***a***1** that is straight and runs perpendicular to the length of the rotating portion **110***a*, and a second portion **113***a***2** that runs diagonally along the length of rotating portion **110***a*, downwardly toward a proximal end of the deployment mechanism **103**. Channel **113***b* includes a first portion **113***b***1** that runs diagonally along the length of the rotating portion **110***a*, downwardly toward a distal end of the deployment mechanism **103**, and a second portion that is straight and runs perpendicular to the length of the rotating portion **110***a*. The point at which first portion **113***a***1** transitions to second portion **113***a***2** along channel **113***a*, is the same as the point at which first portion **113***b***1** transitions to second portion **113***b***2** along channel **113***b*. Channel **113***c* is straight and runs perpendicular to the length of the rotating portion **110***a*. Within each of channels **113***a*, **113***b*, and **113***c*, sit members **114***a*, **114***b*, and **114***c* respectively. Members **114***a*, **114***b*, and **114***c* are movable within channels **113***a*, **113***b*, and **113***c*. Members **114***a*, **114***b*, and **114***c* also act as stoppers that limit movement of rotating portion **110***a*, which thereby limits its axial movement of the shaft **104**.

FIG. **8** shows a cross-sectional view of deployment mechanism **103**. Member **114***a* is connected to the distal portion **109** of the deployment mechanism **103**. Movement of member **114***a* results in retraction of the distal portion **109** of the deployment mechanism **103** to within the proximal portion **110** of the deployment mechanism **103**. Member **114***b* is connected to a pusher component **118**. The pusher component **118** extends through the distal portion **109** of the deployment mechanism **103** and extends into a portion of hollow shaft **104**. The pusher component is involved in deployment of a shunt from the hollow shaft **104**. An exemplary pusher component is a plunger. Movement of member **114***b* engages pusher **118** and results in pusher **118** advancing within hollow shaft **104**.

Reference is now made to FIGS. **9-15**, which accompany the following discussion regarding deployment of a shunt **115** from deployment device **100**. FIG. **9**A shows deployment device **100** in a pre-deployment or insertion configuration. In this configuration, shunt **115** is loaded within hollow shaft **104** (FIG. **9**B). As shown in FIG. **9**B, shunt **115** is only partially within shaft **104**, such that a portion of the shunt is exposed. However, the shunt **115** does not extend beyond the end of the shaft **104**. In other embodiments, the shunt **115** is completely disposed within hollow shaft **104**. The shunt **115** is loaded into hollow shaft **104** such that the shunt abuts pusher component **118** within hollow shaft **104**.

In the pre-deployment or insertion configuration, the distal portion **101***b* of the housing **101** is in an extended position, with spring **121** in a relaxed state (FIG. **9**A). Additionally, in the pre-deployment configuration, the shaft **104** is fully disposed within the sleeve **130** of the distal portion **101***b* of the housing **101** (FIG. **9**B). Pusher **118** abuts shunt **115** (FIG. **9**B).

The deployment mechanism **103** is configured such that member **114***a* abuts a distal end of the first portion **113***a***1** of channel **113***a*, and member **114***b* abut a proximal end of the first portion **113***b***1** of channel **113***b* (FIG. **9**C). In this configuration, the ready indicator **111** is visible through slot **106** of the housing **101**, providing feedback to an operator that the deployment mechanism is in a configuration for deployment of an intraocular shunt from the deployment device **100** (FIG.

9D). In this configuration, the device **100** is ready for insertion into an eye (insertion configuration or pre-deployment configuration).

FIG. **10** shows device **100** in the insertion configuration and inserted into an eye **140**. Any of a variety of methods known in the art may be used to insert devices of the invention into an eye. In certain embodiments, devices of the invention may be inserted into the eye using an ab externo approach (entering through the conjunctiva) or an ab interno approach (entering through the cornea). In particular embodiment, the approach is an ab interno approach as shown Yu et al. (U.S. Pat. No. 6,544,249 and U.S. patent application number 2008/0108933) and Prywes (U.S. Pat. No. 6,007,511), the content of each of which is incorporated by reference herein in its entirety.

FIG. **10** shows an ab interno approach for insertion of device **100** into the eye **140**. In this figure, protrusion **131** at the distal end of the sleeve **130** has been advanced across the anterior chamber **141** to the sclera **142** on the opposite side of the eye **140** from which the device entered the eye **140**. FIG. **10** shows protrusion **131** and sleeve **130** fitted within the anterior chamber angle **143** of the eye **140**. Such insertion and placement is accomplished without the use of an optical apparatus that contacts the eye, such as a goniolens. In certain embodiments this insertion is accomplished without the use of any optical apparatus.

Insertion without the use of an optical apparatus that contacts the eye, or any optical apparatus, is possible because of various features of the device described above and reviewed here briefly. The shape of the protrusion **131** is such that it corrects for an insertion angle that is too steep or too shallow, ensuring that the sleeve **130** is fitted into the anterior chamber angle of the eye, the place for proper deployment of an intraocular shunt. Further, the shape of the protrusion provides adequate surface area at the distal end of sleeve **130** to prevent enough force from being generated at the distal end of sleeve **130** that would result in sleeve **130** entering an improper portion of the sclera **142** (if the insertion angle is too shallow) or entering an improper portion of the iris **144** (if the insertion angle is too steep). Additionally, since the shaft **104** is fully disposed within the sleeve **130**, it cannot pierce tissue of the eye until it is extended from the sleeve **130**. Thus, if the insertion angle is too shallow or too steep, the protrusion **131** can cause movement and repositioning of the sleeve **130** so that the sleeve **130** is properly positioned to fit in the anterior chamber angle of the eye for proper deployment of the shunt. Due to these features of device **100**, devices of the invention provide for deploying intraocular shunts without use of an optical apparatus that contacts the eye, preferably without use of any optical apparatus.

Once the device has been inserted into the eye and the protrusion **131** and the sleeve **130** are fitted within the anterior chamber angle of the eye, the hollow shaft **104** may be extended from within the sleeve **130**. Referring now to FIG. **11** which shows extension of the shaft **104** from within the sleeve **130**, which is accomplished by partial retraction of distal portion **101***b* of housing **101** to within proximal portion **101***a* of housing **101**.

Retraction of the distal portion **101***b* of housing **101** to within proximal portion **101***a* of housing **101** is accomplished by an operator continuing to apply force to advance device **100** after the protrusion **131** and the sleeve **130** are fitted within the anterior chamber angle of the eye. The surface area of protrusion **131** prevents the application of the additional force by the operator from advancing sleeve **130** into the sclera **134**. Rather, the additional force applied by the operator results in engagement of spring mechanism **120** and compression of spring **121** within spring mechanism **120**. Compression of spring **120** results in retraction of distal portion **101***b* of housing **101** to within proximal portion **101***a* of housing **101**. The amount of retraction of distal portion **101***b* of housing **101** to within proximal portion **101***a* of housing **101** is limited by member **122** that acts as a stopper and limits axial retraction of distal portion **101***b* within proximal portion **101***a*.

Retraction of distal portion **101***b* of housing **101** to within proximal portion **101***a* of housing **101** results in extension of hollow shaft **104**, which now extends beyond the distal end of sleeve **130** and advances through the sclera **142** to an area of lower pressure than the anterior chamber. Exemplary areas of lower pressure include Schlemm's canal, the subconjunctival space, the episcleral vein, the suprachoroidal space, or the intra-Tenon's space.

In this figure, a distal end of the shaft is shown to be located within the intra-Tenon's space. Within an eye, there is a membrane known as the conjunctiva, and the region below the conjunctiva is known as the subconjunctival space. Within the subconjunctival space is a membrane known as Tenon's capsule. Below Tenon's capsule there are Tenon's adhesions that connect the Tenon's capsule to the sclera. The space between Tenon's capsule and the sclera where the Tenon's adhesions connect the Tenon's capsule to the sclera is known as the intra-Tenon's space. This figure is exemplary and depicts only one embodiment for a location of lower pressure. It will be appreciated that devices of the invention may deploy shunts to various different locations of the eye and are not limited to deploying shunts to the intra-Tenon's space is shown by way of example in this figure. In this configuration, the shunt **115** is still completely disposed within the shaft **104**.

The distal end of shaft **104** may be beveled to assist in piercing the sclera and advancing the distal end of the shaft **104** through the sclera. In this figure, the distal end of the shaft **104** is shown to have a double bevel (See also FIG. **9**B). The double bevel provides an angle at the distal end of the shaft **104** such that upon entry of the shaft into intra-Tenon's space, the distal end of shaft **104** will by parallel with Tenon's capsule and will thus not pierce Tenon's capsule and enter the subconjunctival space. This ensures proper deployment of the shunt such that a distal end of the shunt **115** is deployed within the intra-Tenon's space, rather than deployment of the distal end of the shunt **115** within the subconjunctival space. Changing the angle of the bevel allows for placement of shunt **115** within other areas of lower pressure than the anterior chamber, such as the subconjunctival space. It will be understood that FIG. **12** is merely one embodiment of where shunt **115** may be placed within the eye, and that devices of the invention are not limited to placing shunts within intra-Tenon's space and may be used to place shunts into many other areas of the eye, such as Schlemm's canal, the subconjunctival space, the episcleral vein, or the suprachoroidal space.

Reference is now made to FIGS. **12**A to **12**C. After extension of hollow shaft **104** from sleeve **130**, the shunt **115** may be deployed from the device **100**. The deployment mechanism **103** is a two-stage system. The first stage is engagement of the pusher component **118** and the second stage is retraction of the distal portion **109** of deployment mechanism **103** to within the proximal portion **110** of the deployment mechanism **103**. Rotation of the rotating portion **110***a* of the proximal portion **110** of the deployment mechanism **103** sequentially engages the pusher component and then the retraction component.

In the first stage of shunt deployment, the pusher component is engaged and the pusher partially deploys the shunt from the deployment device. During the first stage, rotating

portion **110***a* of the proximal portion **110** of the deployment mechanism **103** is rotated, resulting in movement of members **114***a* and **114***b* along first portions **113***a***1** and **113***b***1** in channels **113***a* and **113***b*. Since the first portion **113***a***1** of channel **113***a* is straight and runs perpendicular to the length of the rotating portion **110***a*, rotation of rotating portion **110***a* does not cause axial movement of member **114***a*. Without axial movement of member **114***a*, there is no retraction of the distal portion **109** to within the proximal portion **110** of the deployment mechanism **103**. Since the first portion **113***b***1** of channel **113***b* runs diagonally along the length of the rotating portion **110***a*, upwardly toward a distal end of the deployment mechanism **103**, rotation of rotating portion **110***a* causes axial movement of member **114***b* toward a distal end of the device. Axial movement of member **114***b* toward a distal end of the device results in forward advancement of the pusher component **118** within the hollow shaft **104**. Such movement of pusher component **118** results in partially deployment of the shunt **115** from the shaft **104**.

FIGS. **12**A to **12**C show schematics of the deployment mechanism at the end of the first stage of deployment of the shunt from the deployment device. As is shown FIG. **12**A, members **114***a* and **114***b* have finished traversing along first portions **113***a***1** and **113***b***1** of channels **113***a* and **113***b*. Additionally, pusher component **118** has advanced within hollow shaft **104** (FIG. **12**B), and shunt **115** has been partially deployed from the hollow shaft **104** (FIG. **12**C). As is shown in FIG. **12**C, a portion of the shunt **115** extends beyond an end of the shaft **104**.

FIG. **13** shows device **100** at the end of the first stage of deployment of the shunt **115** from device **100** and into the eye **140**. This figure shows that the distal portion **101***b* of the housing **101** remains retracted within the proximal portion **101***a* of the housing **101**, and that the shaft **104** remains extended from the sleeve **130**. As is shown in this figure, pusher **118** has been engaged and has partially deployed shunt **115** from shaft **104**. As is shown in this figure, a portion of the shunt **115** extends beyond an end of the shaft **104** and is located in the intra-Tenon's space.

Reference is now made to FIGS. **14**A to **14**C. In the second stage of shunt deployment, the retraction component of deployment mechanism is engaged and the distal portion of the deployment mechanism is retracted to within the proximal portion of the deployment mechanism, thereby completing deployment of the shunt from the deployment device. During the second stage, rotating portion **110***a* of the proximal portion **110** of the deployment mechanism **103** is further rotated, resulting in movement of members **114***a* and **114***b* along second portions **113***a***2** and **113***b***2** in channels **113***a* and **113***b*. Since the second portion **113***b***2** of channel **113***b* is straight and runs perpendicular to the length of the rotating portion **110***a*, rotation of rotating portion **110***a* does not cause axial movement of member **114***b*. Without axial movement of member **114***b*, there is no further advancement of pusher **118**. Since the second portion **113***a***2** of channel **113***a* runs diagonally along the length of the rotating portion **110***a*, downwardly toward a proximal end of the deployment mechanism **103**, rotation of rotating portion **110***a* causes axial movement of member **114***a* toward a proximal end of the device. Axial movement of member **114***a* toward a proximal end of the device results in retraction of the distal portion **109** to within the proximal portion **110** of the deployment mechanism **103**. Retraction of the distal portion **109**, results in retraction of the hollow shaft **104**. Since the shunt **115** abuts the pusher component **118**, the shunt remains stationary at the hollow shaft **104** retracts from around the shunt **115**. The shaft **104**, retracts completely to within the sleeve **130** of the distal portion **101***b* of the housing **101**. During both stages of the deployment process, the housing **101** remains stationary and in a fixed position.

Referring to FIG. **14**A, which shows a schematic of the deployment mechanism at the end of the second stage of deployment of the shunt from the deployment device. As is shown in FIG. **14**A, members **114***a* and **114***b* have finished traversing along second portions **113***a***2** and **113***b***2** of channels **113***a* and **113***b*. Additionally, distal portion **109** has retracted to within proximal portion **110**, thus resulting in retraction of the hollow shaft **104** to within the housing **101**.

FIG. **14**B shows a schematic of the device **100** in the eye after the second stage of deployment has been completed. FIG. **14**B shows that the distal portion **101***b* of the housing **101** remains retracted within the proximal portion **101***a* of the housing **101**. As is shown in these FIGS. **14**B and **14**C, shaft **104** has withdrawn through the sclera **134** and has fully retracted to within sleeve **130**. At completion of the second stage of deployment, a distal portion of the shunt **115** has been deployed and resides in the intra-Tenon's space, a middle portion of the shunt **115** spans the sclera, and a proximal portion of shunt **115** has been deployed from shaft **104** yet still resides within sleeve **130**. The proximal portion of the shunt **115** still abuts pusher **118**.

Referring to FIG. **14**C, in the post-deployment configuration, the deployed indicator **119** is visible through slot **106** of the housing **101**, providing feedback to the operator that the deployment mechanism **103** has been fully engaged and that the deployment mechanism **103** has completed its second stage of deployment.

Referring to FIG. **15**, which shows a schematic of the device **100** after completion of deployment of the shunt **115** from the device **100** and in to the eye **140**. After completion of the second stage of the deployment by the deployment mechanism **103**, as indicated to the operator by visualization of deployed indicator **119** through slot **106** of the housing **101**, the operator may pull the device **100** from the eye **140**. Backward force by the operator reengages spring mechanism **120** and results in uncoiling of spring **121**. Uncoiling of spring **121** proceeds as the proximal portion **101***a* of housing **101** is pulled from the eye **140**. Such action causes distal portion **101***b* to return to its extended state within proximal portion **101***a* of housing **101**. Continued backward force by the operator continues to pull the device **100** from the eye **140**. As the device **100** is continued to be pulled from the eye, the sleeve **130** is also pulled backward and the proximal portion of the shunt **115** is exposed from within the sleeve **130** and resides within the anterior chamber **141** of the eye **140**. The operator continues to apply backward force until the device **100** is completely withdrawn from the eye **140**.

Combinations of Embodiments

As will be appreciated by one skilled in the art, individual features of the invention may be used separately or in any combination. Particularly, it is contemplated that one or more features of the individually described above embodiments may be combined into a single shunt.

Incorporation by Reference

References and citations to other documents, such as patents, patent applications, patent publications, journals, books, papers, web contents, have been made throughout this disclosure. All such documents are hereby incorporated herein by reference in their entirety for all purposes.

Equivalents

The invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The foregoing embodiments are therefore to be considered in all respects illustrative rather than limiting on the invention described herein.

What is claimed is:

1. A system for deploying an intraocular shunt, the system comprising:

a locking mechanism; and

a device configured to hold and deliver an intraocular shunt into an eye, the device comprising:

a housing comprising a proximal portion and a distal portion, the distal portion being movable within the proximal portion, the distal portion being configured to mate with the locking mechanism to prevent movement of the distal portion when the locking mechanism is engaged, the distal portion comprising a sleeve;

a deployment mechanism at least partially disposed within the housing; and

a hollow shaft coupled to the deployment mechanism, the shaft being configured to hold the intraocular shunt at least partially within the shaft; and

wherein the device has an insertion configuration in which the hollow shaft is fully disposed within the sleeve.

2. The system according to claim **1**, wherein the locking mechanism is configured to fit at least partially around the distal portion of the device.

3. The system according to claim **1**, wherein the locking mechanism comprises teeth that mate with holes in the distal portion of the device.

4. The system according to claim **1**, further comprising an intraocular shunt that is at least partially disposed within the shaft.

5. The system according to claim **1**, wherein a distal end of the distal portion forms an angle that is identical to an anterior chamber angle of an eye.

6. The system according to claim **1**, wherein the deployment mechanism further comprises a member that limits axial retraction of the distal portion of the housing.

7. The system according to claim **1**, wherein the distal portion comprises a capsule configured to mate with the locking mechanism.

8. The system according to claim **1**, wherein the device comprises a shaft exposure configuration in which the shaft at least partially protrudes from the sleeve.

9. The system according to claim **8**, wherein, when in the shaft exposure configuration, retraction of the distal portion into the proximal portion of the housing exposes a distal portion of the hollow shaft from the sleeve.

10. The system according to claim **1**, wherein the deployment mechanism comprises a pusher component and a retraction component.

11. The system according to claim **1**, wherein the hollow shaft is a needle.

12. The system according to claim **1**, wherein the locking mechanism comprises a pair of arms.

13. A system for deploying an intraocular shunt, the system comprising:

a locking mechanism; and

a device configured to hold and deliver an intraocular shunt into an eye, the device comprising:

a housing comprising a proximal portion and a distal portion, the distal portion being movable within the proximal portion, the distal portion being configured to mate with the locking mechanism to prevent movement of the distal portion when the locking mechanism is engaged;

a deployment mechanism at least partially disposed within the housing, the deployment mechanism comprising a pusher component, a retraction component, and a rotatable component, wherein rotation of the rotatable component sequentially engages the pusher component and then the retraction component; and

a hollow shaft coupled to the deployment mechanism, the shaft being configured to hold the intraocular shunt at least partially within the shaft.

14. The system according to claim **13**, further comprising an intraocular shunt that is at least partially disposed within the device.

15. The system according to claim **13**, wherein the distal portion comprises a capsule configured to mate with the locking mechanism.

16. The system according to claim **13**, wherein the pusher component is configured to push the shunt to partially deploy the shunt from within the shaft, and the retraction component is configured to retract the shaft from around the shunt.

17. The system according to claim **13**, wherein the deployment mechanism further comprises at least one member that limits axial movement of the shaft.

18. The system according to claim **13**, wherein the hollow shaft is a needle.

19. The system according to claim **13**, wherein the device is a handheld device.

20. The system according to claim **13**, wherein the device further comprises an indicator mechanism, formed on the housing and the deployment mechanism, that provides feedback to an operator as to the state of the deployment mechanism.

21. The system according to claim **20**, wherein the indicator mechanism comprises a slot, formed in the housing and extending along the deployment mechanism, for providing visual indication of the state of the deployment mechanism.

22. A system for deploying an intraocular shunt, the system comprising:

a locking mechanism; and

a device configured to hold and deliver an intraocular shunt into an eye, the device comprising:

a housing comprising a proximal portion and a distal portion, the distal portion being movable within the proximal portion, the distal portion being configured to mate with the locking mechanism to prevent movement of the distal portion when the locking mechanism is engaged, the distal portion comprising a sleeve, a distal end of the sleeve comprising a protrusion;

a deployment mechanism at least partially disposed within the housing; and

a hollow shaft coupled to the deployment mechanism, the shaft being configured to hold the intraocular shunt at least partially within the shaft.

23. The system according to claim **22**, wherein the device has an insertion configuration in which the hollow shaft is fully disposed within the sleeve.

24. The system according to claim **22**, wherein the protrusion provides resistance against advancement of the device when the protrusion contacts scleral tissue on an inside of an anterior chamber.

25. The system according to claim **22**, wherein the protrusion comprises a flat bottom portion and an angled top portion that is oriented at an angle with respect to the flat bottom portion.

26. The device according to claim **25**, wherein the angle is an acute angle configured to be substantially identical to an anterior chamber angle of an eye.

27. The system according to claim **22**, wherein the locking mechanism comprises a pair of arms.

28. The system according to claim **22**, wherein the distal portion comprises a capsule configured to mate with the locking mechanism.

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